United States
Environmental Protection
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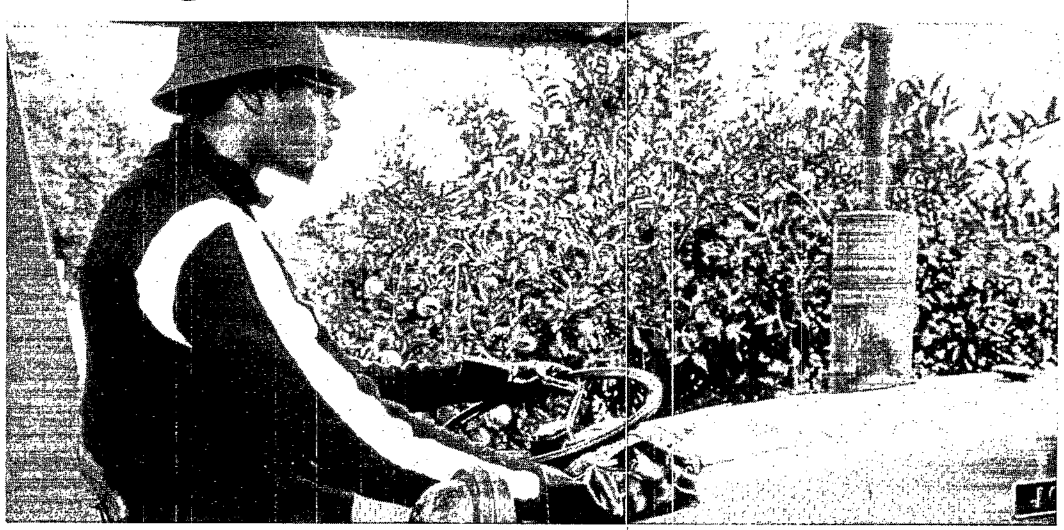
Prevention, Pesticides and
Toxic Substances

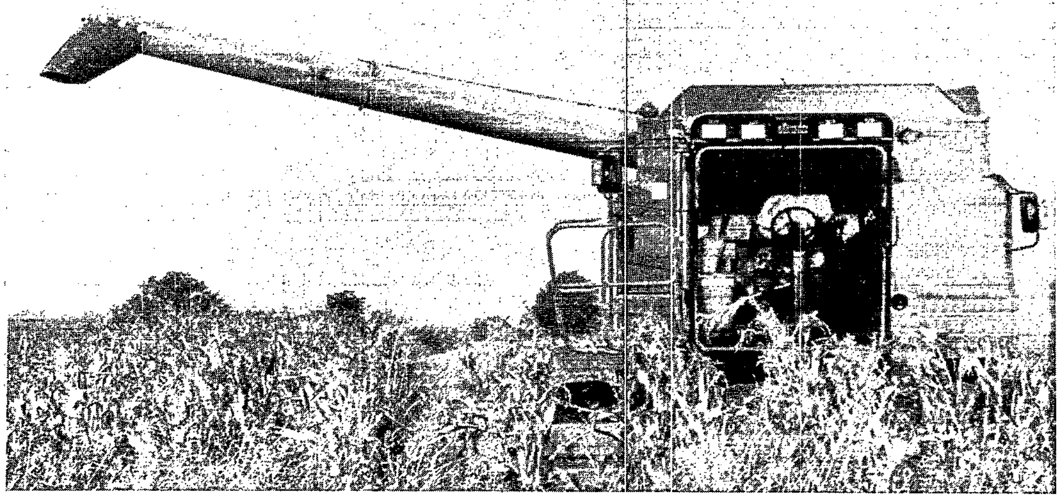
EPA-750-b-92-001
May 1993

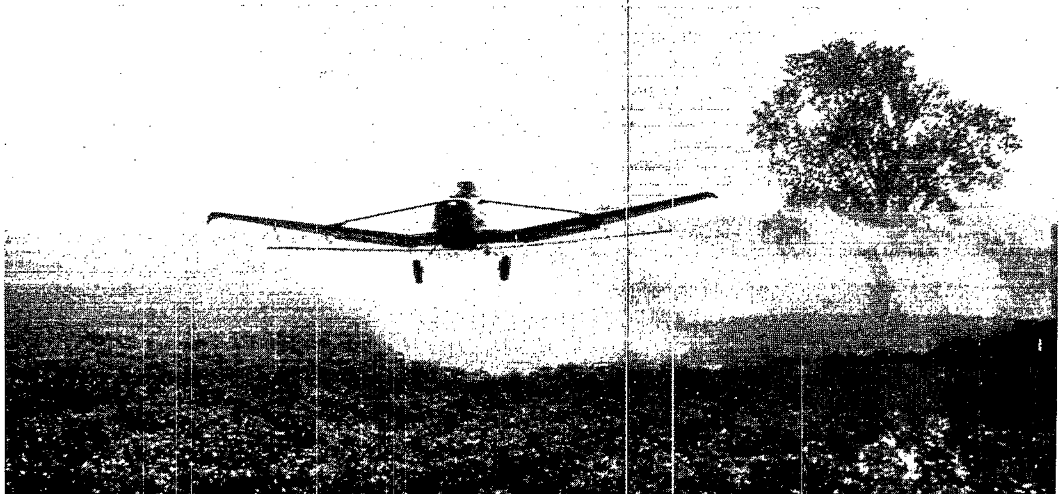
Occupational Safety and Health Administration

EPA

A Guide To Heat Stress In Agriculture







WORKER PROTECTION STANDARD
EPA

There are other materials about the Worker Protection Standard developed by EPA, including a safety poster, handbooks on pesticide safety for pesticide handlers and for agricultural workers, and a manual for agricultural employers. For more information about safety training and about the revised Worker Protection Standard, contact:

Occupational Safety Branch (7506C)
Office of Pesticide Programs
U.S. Environmental Protection Agency
401 M Street, S. W.
Washington, D.C. 20460
(703) 305-7666

For More Information

If you need more information about the Worker Protection Standard or have questions or concerns about pesticides, contact the agency responsible for regulating pesticides in your area or the EPA Regional Office nearest you.

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Environmental Protection
Agency

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Safety and Health
Administration

EPA

A Guide To Heat Stress In Agriculture

WORKER PROTECTION STANDARD
EPA

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Printed with Soy/Canola Ink on paper that contains at least 50% recycled fiber

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Boston, MA 02114
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*These states and territories operate their own OSHA-approved job safety and health programs (Connecticut and New York plans cover public employees only). States with approved programs must have a standard that is identical to, or at least as effective, as the Federal standard.

PREFACE

This guide was written to help private and commercial pesticide applicators and agricultural employers protect their workers from heat illness. It applies recognized heat stress management principles to the particular conditions of agriculture.

Special emphasis has been given to the problems of controlling heat stress among pesticide handlers and "early entry" workers (workers who go into an area while entry is restricted after treatment with pesticides) who must wear protective gear. EPA's revised Worker Protection Standard requires that these workers be instructed in the prevention, recognition, and first-aid treatment of heat illness and that they not be allowed or directed to perform handling or early entry activities unless appropriate measures are taken, if necessary, to prevent heat illness.

The basic program presented here is intended to be "best practice." Some items will not be practical in every particular situation and agricultural establishments will need to adapt this program to their specific conditions of work.

Eight principal sources were used in developing this guide. These are listed as references 1 to 8 in the back. Additional references are cited throughout the text and also listed in the back.

Note: The revised Worker Protection Standard uses the term "personal protective equipment" or "PPE" to designate devices and garments worn to protect the body against contact with pesticides or pesticide residues. The revised standard distinguishes between certain items of work clothing, such as long-sleeved shirts and long pants, which had been included under the definition of "protective clothing" in an earlier standard, and more protective garments. However, the term "protective clothing" is also in general use in occupational safety and health to designate any article offering skin and/or body protection. To avoid confusion, the term "protective clothing" is not used here.

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ACKNOWLEDGEMENTS

This guide was prepared by the Occupational Safety Branch in the Field Operations Division of EPA's Office of Pesticide Programs in conjunction with OSHA. Steve Shapiro was the principal author. EPA and OSHA are issuing this guide jointly.

Many people generously provided comments, valuable information, and other assistance, greatly improving its contents. EPA and OSHA are responsible for the guide's contents; but to the extent this guide is helpful to people in controlling heat stress, much of the credit must go to the following persons:

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Most photographs by Earl Dotter (photo on page 26 courtesy of Steele Inc.). Editing, design and typesetting prepared under Contract #OW-1867-NALX.

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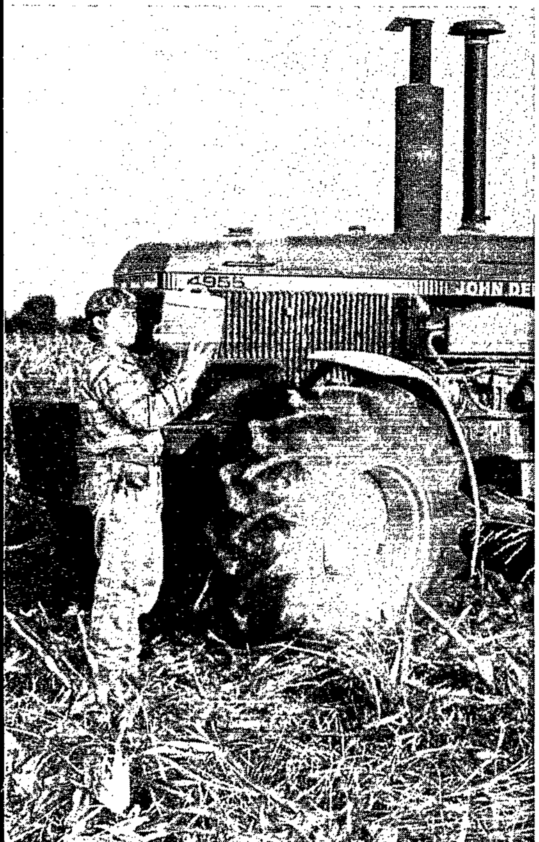
INTRODUCTION



When the body becomes overheated, workers get weaker, become tired sooner, and may be less alert, less able to use good judgment, and less able to do their jobs well.

WHAT IS HEAT STRESS?

Heat stress is the buildup in the body of heat generated by the muscles during work and of heat coming from warm and hot environments.

Heat exhaustion and heat stroke result when the body is subjected to more heat than it can cope with.

Table 1 on page 4 lists the most common forms of heat illness and first aid measures for treating them.

When the body becomes overheated, less blood goes to the active muscles, the brain, and other internal organs. Workers get weaker, become tired sooner, and may be less alert, less able to use good judgment, and less able to do their jobs well.

As strain from heat becomes more severe, there can be a rapid rise in body temperature and heart rate. Workers may not realize that this is happening because there is no pain. Mental performance can be affected with an increase in body temperature of 2°F above normal. An increase of 5°F can result in serious illness or death. The most serious illness is heat stroke. Its effects can include confusion, irrational behavior, convulsions, coma, and even death. Heat stroke can make survivors very sensitive to heat for months and cause varying degrees of brain and kidney damage.[12, 36, 49]

More than 20 percent of people afflicted by heat stroke die, even young and healthy adults. An average of nearly 500 people are killed each year in the United States by the effects of heat. During the heat wave of 1980, over 1700 people died from heat-related illness.[38, 57]

Exposure to heat can have other effects as well. Elevated temperatures in the scrotum for a short period of time can cause men to become relatively infertile for two to three months. The effect of heat on pregnancy is unclear, but it has been recommended that high increases in body temperature be especially avoided during early pregnancy. Children are more susceptible to heat strain than adults.[27, 28, 41, 44, 67, 74]

During hot weather, heat illness may be an underlying cause of other types of injuries, such as heart attacks on the job, falls, and equipment accidents arising from poor judgment.

THE NEED FOR A HEAT STRESS CONTROL PROGRAM IN AGRICULTURE

In some regions, there are times during the growing season when the temperature stays above 90°F, even at night. High air temperatures and humidities put agricultural workers at special risk of heat illness. Workers Compensation claims for heat illness among agricultural

REPORTS OF AGRICULTURAL WORKERS WHO BECAME ILL WHILE WORKING IN THE HEAT

Decedent was identified as ______, reportedly 34 years old. He was pronounced Dead On Arrival at 19:22, on 5-26.

He worked for two days for the firm of ______.

At about 16:00, he became disoriented while working in the fields. Apparently the paramedics and an ambulance were called at about 17:15. When he arrived at ______ Medical Center, his temperature was over 107 degrees. This was after spending the prior hour riding in an air conditioned ambulance.

—K.S., Deputy Coroner

Received a call reporting that ______, female adult, 18, had been pronounced dead in the Medical Intensive Care Unit by Dr. French at 13:59, May 30.

The decedent had been taken to ______ Hospital by her father at 14:30, May 28, after collapsing while working in a cotton field. The exact location could not be determined. Upon arrival at the hospital, the decedent had a rectal temperature of 107.5 degrees Fahrenheit. She was given oxygen and packed in ice and by 15:10 her temperature had dropped to 103.5. She was suffering from seizures and a constant flow of yellow, watery diarrhea. She was unresponsive the entire time she was at the hospital and her pupils were three to four millimeters wide.

She was transferred to the Medical Intensive Care Unit, where efforts were made to regulate her body temperature and it was reduced to 100.4 degrees Fahrenheit. The seizures continued, however, and she began to have myocardial and renal (heart and kidney) failure and disseminated intravascular coagulation (blood clots throughout her body). She was on dialysis when she died.

The decedent's family reported that she had been working in the fields for three days prior to her collapse. She had taken a tylenol for a headache around noon, May 28, but immediately threw it up.

The United States Weather Bureau reported that the high temperatures for May 25 through May 28 were 93, 96, 102, and 107 degrees Fahrenheit, respectively.

—P. H., Deputy Coroner

On September 3, ______ became ill while mixing, loading, and applying pesticides to a strawberry field. This person has worked for ______ Farms for 3+ years. He has been spraying for only one year.

He said he felt fine when starting work at 7:30 a.m. While applying, he wore rubber boots, rubber gloves, torn rubber pants, a rubber jacket, goggles, and a dust mask. He was working with malathion, benomyl, sulfur, and an adjuvant. He took off his rubber jacket at noon due to the heat. Around 4 p.m., he developed symptoms of dizziness, nausea, vomiting, and lethargy. The grower told him to buy a bottle of olive oil and drink it as a remedy. He went home and drank most of a bottle.

Later that night, he was taken to ______ Community Hospital. He was admitted and given a shower. A blood sample was drawn to determine cholinesterase activity. The results showed that plasma cholinesterase was 28% of low laboratory normal and red blood cell cholinesterase was 32% of low laboratory normal. He was treated with atropine and released from the hospital five days later. He returned to work without missing any additional days from work.

When asked why this worker was wearing a dust mask as opposed to a respirator approved for use with organic vapors, his employer said that respirators for organic vapors were available, but the workers would take them off whenever it got hot.

—Pesticide Enforcement Branch

The deceased came to ______ on June 20 and inquired if he could be hired, as he needed the work and had experience. He began work the following day.

On June 27, while engaged in hoeing weeds, he collapsed about 4 p.m. and was driven to ______ Hospital via pickup truck. On June 29 he was transferred to ______ Hospital, where he died on July 9.

Autopsy indicated the deceased, 55, died as a result of hyperthermia (heat stroke) with a significant contributing factor of chronic ethylism (poisoning by alcohol).

—Harry D. Allendorf, Area Director

9, 35, 45, 60, 72

workers are among the highest of any occupation.[37, 55]

Pesticide handlers and early entry workers are at even greater risk. The special clothing and equipment they wear for protection from exposure to pesticides can restrict the evaporation of sweat, blocking the body's natural way of cooling itself, which results in a buildup of body temperature. Exposure to certain pesticides can also produce sweating and there can be combined effects with exposure to heat. In addition, pesticides are absorbed through hot, sweaty skin more quickly than through cool skin.

A program to prevent heat illness will:

- **Protect health.** Heat illness is preventable. When less severe forms occur, they can be treated before they become life-treatening.

- **Improve safety.** Workers with mild effects of heat illness are more likely to have accidents and use poor judgment.

- **Increase productivity.** People work slower and less efficiently when they are under too much strain from heat.

This guide presents steps employers can take to control heat stress and protect workers from heat illness. The methods include some practices you may already follow, whether or not you recognize them as part of a heat stress control program.

A summary of key points to follow begins on page 5. A more detailed program can be found on pages 8 through 33. Supplementary information can be found in the appendices at the back of this guide.

Agricultural workers are at special risk of heat illness. Pesticide handlers and early entry workers are at even greater risk.

Employers should begin with the basic program starting on page 8 and adapt it to their particular needs and circumstances.*

Employers, supervisors, and workers each have an essential role to play in preventing heat illness. What is essential with employers is their commitment to their heat stress control program. What is essential with supervisors and employees is their following these procedures, gaining experience, and developing good judgment using the principles in this guide.

*Employers wishing to develop a more detailed program than presented here should consult references 1 through 8 at the back of the Guide.

Table 1

HEAT ILLNESSES AND FIRST AID MEASURES

Illness	Signs and Symptoms	Cause and Problem	Treatment*
Early heat illness	Mild dizziness, fatigue, or irritability; decreased concentration; impaired judgment	Reduced flow of blood to the brain May lead to heat exhaustion or heat stroke	Loosen or remove clothing Rest in shade 30 minutes or more Drink water
Heat rash ("prickly heat")	Tiny, blister-like red spots on the skin; pricking sensations Commonly found on clothed areas of the body	Sweat glands become plugged and inflamed from unrelieved exposure of skin to heat, humidity, and sweat	Clean skin, apply mild drying lotion or cornstarch Wear loose clothing Preventable by regular bathing and drying the skin and by periodic relief from humid conditions of work See physician if rash persists
Heat cramps	Painful spasms of leg, arm, or abdominal muscles Heavy sweating, thirst Occur during or after hard work	Loss of body salt in sweat May be totally disabling	Loosen clothing Drink *lightly* salted beverages Massage [76] Rest
Heat exhaustion	Fatigue, headache, dizziness, muscle weakness, loss of coordination, fainting, collapse Profuse sweating; pale, moist, cool skin; excessive thirst, dry mouth; dark yellow urine Fast pulse, if conscious Low or normal oral temperature, rectal temperature usually 99.5-101.3°F May also have heat cramps, nausea, urge to defecate, rapid breathing, chills, tingling of the hands or feet, confusion, giddiness, slurred speech, irritability	Dehydration, lack of acclimatization; reduction of blood in circulation, strain on circulatory system, reduced flow of blood to the brain Worker may resist treatment May lead to heat stroke	Removel to cooler, shaded area as quickly as possible Rest lying down If conscious, have worker drink as much water as possible *Do not give salt* If unconscious or if heat stroke is also suspected, treat for heat stroke until proven otherwise [36] Loosen or remove clothing Splash cold water on body Massage legs and arms If worker collapsed, get evaluation by physician, nurse, or EMT before worker leaves for the day; shower in cold water; rest for balance of day and overnight
Heat stroke IMMEDIATE TREATMENT REQUIRED	LIFE-THREATENING MEDICAL EMERGENCY Often occurs suddenly Headache, dizziness, confusion, irrational behavior, coma Sweating may slow down or stop Fast pulse, if conscious Rapid breathing Rectal temperature 104°F and over May also have convulsions, nausea, incoherent speech, very aggressive behaviour	Sustained exertion in heat, lack of acclimatization, dehydration, individual risk factors (see page 15); reduced flow of blood to the brain and other vital organs, body's temperature-regulating system fails, body cannot cool itself Risk of damage to vital organs, including the heart, brain, central nervous system, liver, and kidney Worker may resist treatment BRAIN DAMAGE AND DEATH CAN RESULT, EVEN WITH PROMPT TREATMENT	Move to a shaded area Remove outer clothing/shoes Immediately wrap in wet sheet, pour water on and fan vigorously, avoid over-cooling Treat shock if present, once temperature is lowered If worker vomits, make sure all vomit is cleared from mouth and nose to prevent choking on vomit Transport to nearest medical treatment facility at once While awaiting or during transport, elevate legs, continue pouring on water and fanning If conscious, have worker drink as much water as possible *Do not give salt*

*Combined effects of heat illness and pesticide poisoning must be considered with pesticide handlers and "early entry" workers. See "Heat illness and pesticide poisoning," page 7.

CONTROLLING HEAT STRESS MADE SIMPLE

Drinking enough water to replace body fluids lost through sweating and taking rest breaks for cooling the body down are key elements for controlling heat stress.

KEY ELEMENTS

1. **Water.** Make sure workers drink enough water to replace body fluid lost through sweating.
2. **Acclimatization.** Have workers gradually adjust to working in the heat.
3. **Rest breaks.** Have workers take periodic breaks in a shaded or air-conditioned area whenever possible.
4. **Monitoring environmental conditions and workers.** Check temperature and humidity at least hourly when workers are working in hot environments and monitor workers' response to working in the heat.

BASIC STEPS

■ **Train workers and supervisors** in how to control heat stress and to recognize, prevent, and treat heat illnesses.

■ **Take into account the weather, workload, protective gear to be worn, and condition of the workers.**

■ *Weather.* The danger of heat stress increases with higher temperature and humidity and with direct sunlight (sun without cloud cover). The full heating effect of the sun can equal an increase of up to 13°F in air temperature. Wind reduces the risk of heat illness by increasing the evaporation of sweat when normal clothing is worn.

■ *Workload.* The body generates more heat during heavy work than during light or moderate work. Applying pesticides on foot generates more body heat than applying pesticides from a tractor or truck.

■ *Clothing and protective equipment.* The evaporation of sweat on the skin helps cool a person. The more clothes a person wears, the slower sweat evaporates and the longer it takes to cool off. Coated and non-woven synthetic protective garments effectively block evaporation of sweat. When pesticide handlers and early entry workers wear protective garments, they get hotter than when they wear normal work clothes.

■ *The age and physical condition of the workers.* Younger workers, well-rested workers, and physically-fit workers are less likely to suffer heat illness than other workers. But even workers in good shape can become seriously ill from heat. Many drugs, including alcohol and cold and allergy medications containing antihistamines, increase the risk of heat illness.

■ *Whether the workers are used to working in the heat.* Workers who have gradually adjusted to working in a warm or hot environment are less likely to become ill.

■ **Determine minimum amounts of water workers should drink.** (See Tables 6 and 7, pages 18-19.) Thirst does not give a good indication of how much water a person needs to drink.

■ **Adjust work practices for the conditions of each day.**

■ *Schedule heavy work and pesticide handling requiring protective garments and equipment for the cooler hours of the day whenever possible.*

■ *Set up work/rest cycles* so that workers work and rest for specific periods of time. (Tables 6 and 7)

By following these steps, you will control many heat stress problems. But you should also be prepared for times when, regardless of your efforts, you or your workers get too hot. When this happens, you must:


Exposure to pesticides and other toxic agents increases the risk of heat illness.

Drinking water frequently throughout the work day helps keep the body hydrated. Thirst does not give a good indication of how much water a person needs to drink.

■ **Shorten the length of work periods and increase the length of rest periods.**

■ **Give workers shade or cooling** by various means, such as cooling vests, canopies, awnings, and air conditioning. Wearing a brimmed hat to shade the head can be particularly helpful.

■ **Reassign workers** who are less fit to lighter work.

■ **Halt work altogether under extreme conditions.**

Even using these procedures, some work under certain conditions will always make workers hot. A heat stress control program, however, will help prevent extreme situations from arising and enable you to handle those situations which do arise.

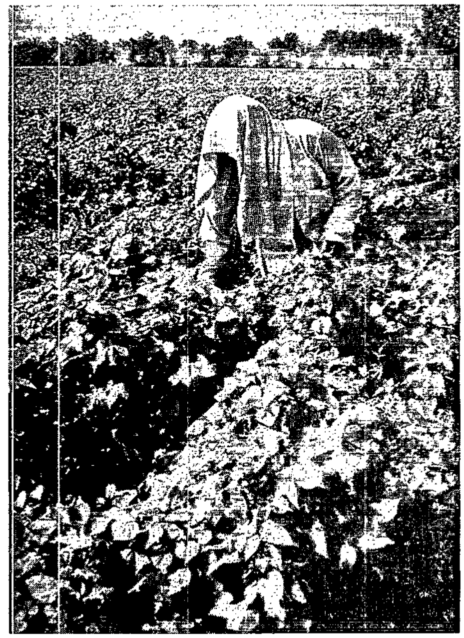
■ **Give first aid when workers become ill.** Early recognition and immediate treatment are key to first aid for heat illness. Mild overheating and heat exhaustion can quickly lead to heat stroke, which is a life-threatening medical emergency.[36]

Treatment for overheating includes rest in a cool, shaded area and drinking plenty of water. Even after the skin has cooled and a person feels comfortable, internal body temperature can remain high. Once a worker has become overheated, internal body cooling requires 30 minutes or more.

Table 1 on page 4 and Step 8 on page 32 give more details on the treatment of heat illness.

HEAT ILLNESS AND PESTICIDE POISONING

When a pesticide handler becomes ill from working with organophosphate or carbamate insecticides in warm and hot environments, it can be hard to tell whether the handler is suffering from heat exhaustion or from pesticide poisoning. While these illnesses share some similar symptoms, their treatments differ. Table 2 compares these symptoms.



Shading—with awnings, canopies, and head coverings—helps reduce the heat stress from the sun.

Combined problems of heat illness and pesticide poisoning may also occur. If there is any doubt about what the illness is, get medical help immediately. Both pesticide poisoning and heat stroke can be life-threatening and require prompt treatment.

Table 2

COMPARISON OF SYMPTOMS OF HEAT EXHAUSTION AND ORGANOPHOSPHATE/CARBAMATE POISONING

Heat Exhaustion	Organophosphate/Carbamate Poisoning
Sweating	Sweating
Headache	Headache
Fatigue	Fatigue
DRY membranes	*MOIST membranes*
Dry mouth	*Salivation*
No tears	*Tears*
No spit present	*Spit present in mouth*
FAST pulse (slow if person has fainted)	*SLOW pulse*
Nausea	*Nausea and diarrhea*
DILATED pupils	*Possible SMALL pupils*
Central nervous system depression	Central nervous system depression
Loss of coordination	Loss of coordination
Confusion	Confusion
Fainting (recovery prompt)	*Coma (can't waken)*

A BASIC PROGRAM TO CONTROL HEAT STRESS

People vary in size, body temperature, and resistance to disease, heat, and cold. As a result, heat affects different people in different ways: some people can work comfortably at higher temperatures while others get sick from heat stress.

A heat stress control program should be geared to protecting all workers at an establishment, especially those who are not in the best physical shape. Table 3 below outlines a basic program for doing this.

Table 3

A BASIC PROGRAM FOR CONTROLLING HEAT STRESS

STEP 1: Assign responsibility for heat stress problems.

STEP 2: Train workers and supervisors.

- Train workers and supervisors in the control of heat stress and the recognition, prevention, and treatment of heat illnesses.
- Conduct safety meetings during heat spells.

STEP 3: Acclimatize workers when they begin to work under hot conditions.

- Assign a lighter workload for 5-7 days.
- Allow longer rest periods for 5-7 days.
- Assign work in the heat for at least 100 minutes each day.
- Gradually increase the time of work in the heat each day.
- Watch workers' response to working in the heat closely for 5-7 days.

STEP 4: Account for the conditions of work and of the workers.

- Check weather conditions.
- Consider how heavy the work is.
- Consider whether the worker is to wear protective garments and equipment.
- Check if the worker is or has recently been sick or has had a sharp loss in weight.
- Check whether the worker is rested, is taking any medications, or appears to have consumed alcohol that day.

STEP 5: Manage work activities.

- Set up rest breaks.
- Rotate tasks among workers.
- Schedule heavy work for cooler hours.
- Postpone non-essential tasks during heat spells.
- Monitor environmental conditions and workers.

STEP 6: Establish a drinking water program.

STEP 7: Take additional measures, as appropriate.

- Provide special cooling garments.
- Select lightest weight or "breathable" protective garments and cooler respirators that give adequate protection.
- Provide shade.
- Use air-conditioned mobile equipment.
- Modify pesticide usage and handling to reduce need for protective garments and equipment.

STEP 8: Give first aid when workers become ill.

- Set up a first aid program.
- Take heat stroke victims to the nearest medical treatment facility.
- Follow up on incidents of heat illness.

STEP 1 Assign Responsibility For Heat Stress Problems

Controlling heat stress is the responsibility of both management and workers. Government regulations require that employers provide working conditions that will not cause illness or death from the effects of heat, as well as from other recognized hazards.*

An employer should designate one person to have principal responsibility for managing the heat stress program. This helps ensure that heat stress management will be tended to continually. Who this person is may depend on the size of the operation. At very small operations, the person responsible for managing a heat stress program might be the owner or a specially designated worker. At larger establishments, depending on circumstances, this person might be the owner, a manager, a foreman, a crew leader, or a person who has other responsibilities for managing health and safety. The manager should be knowledgeable in recognizing, evaluating, and controlling heat stress.

Managers' duties can include:

- Monitoring environmental conditions.
- Making work assignments.
- Setting up appropriate work/rest cycles.
- Adjusting work practices as necessary.
- Making sure workers drink enough water.
- Treating heat stress problems.
- Following up on incidents of heat illness to prevent their recurrence.
- Overseeing heat acclimatization and heat stress training of new workers. This can include conducting worker training.
- Conducting periodic safety meetings during heat spells.

Workers are responsible for:

- Carrying out instructions and training for controlling heat stress, including being alert to signs of heat illness in themselves and others.
- Drinking enough water before, during, and after work.
- Monitoring their recovery heart rate, as needed.
- Reporting and responding to heat stress problems.
- Personal hygiene, not using drugs, getting adequate rest and sleep.

Workers need to be alert to signs of heat illness in themselves and others.

Workers are responsible for drinking enough water before, during, and after work.

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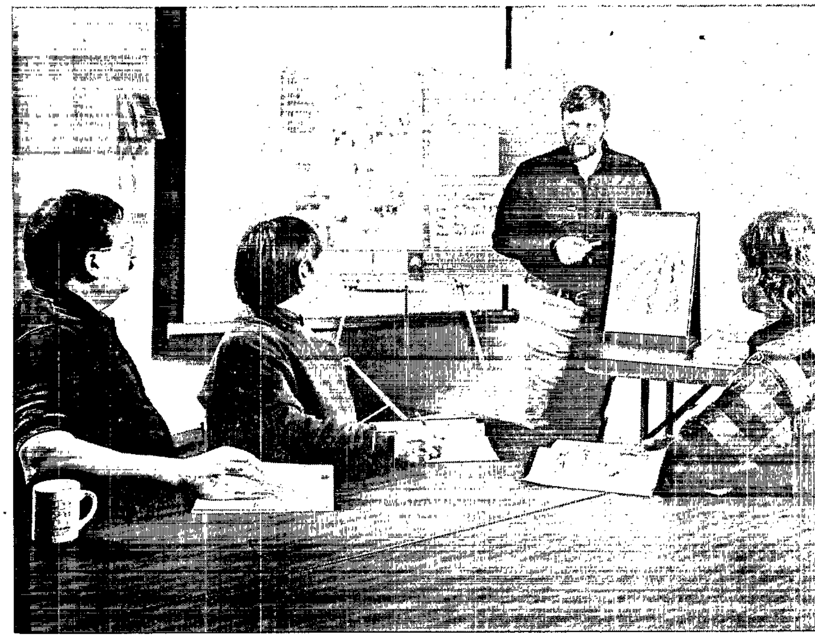
* 29 U.S. Code 654 (a)(1)

STEP 2 Train Workers And Supervisors



Training should include information on how heat stress affects judgment, reduces productivity, and increases the likelihood of accidents and injuries.

Worker and supervisor training should include:

■ The purpose of the establishment's heat stress program.

■ The causes, risk factors, and types of heat illness.

■ The establishment's standard procedures for controlling heat stress and preventing heat illness, including:

■ Setting work/rest cycles that account for the weather, work to be done, and protective garments and equipment (where required).

■ Drinking sufficient water before work, during breaks, and after work.

■ Avoiding the use of alcohol, illegal drugs, and non-prescription medications.

■ Learning acclimatization procedures and how the acclimatization process works.

■ Taking pulse counts under more severe heat stress conditions after the start of rest breaks to measure the recovery heart rate. A heart rate above 110 beats per minute after one minute of rest is an indication of strain from the heat, that body temperature may be rising, and that corrective actions, such as shortening work periods, need to be taken.

■ Worker and supervisor responsibilities under the heat stress program.

■ Information on heat stress and its effects, including:

■ How heat stress affects judgment, reduces productivity, and increases the likelihood of accidents and injuries. This subject should cover examples of the kinds of accidents which can happen during work and how loss of judgment increases the chances of these accidents happening.

■ How some things which happen off the job — such as alcohol and drug use and failure to drink enough water or get enough sleep — can increase the risk of heat illness at work.

■ How to be vigilant and recognize symptoms of heat illness in oneself and signs of heat illness in other workers. People suffering from severe heat illness, such as heat exhaustion, may become unaware of their surroundings, overactive, uncoordinated, and mentally confused. Workers suffering from heat exhaustion cannot be expected to be able to take care of themselves.

■ Procedures for first aid and getting emergency medical care.

■ (Where applicable) Requirements for protective garments and equipment, how protective gear can increase heat stress, and additional measures to control heat stress, including:

■ The protection that protective garments and equipment give, the reasons why wearing them is necessary, and the hazards of not wearing them.

■ A frank discussion of how protective garments and equipment can be inconvenient and uncomfortable, increase the risk of heat illness, and decrease mobility, vision, and hearing; and a discussion of how to minimize these problems.

■ Working for shorter periods and taking longer rest breaks when necessary, drinking more water, and using cooling garments.

An employer should conduct training when a new worker starts work during warm weather and conduct full refresher training at the onset of warm weather each growing season. During hot weather, an employer should hold periodic safety meetings to review and emphasize procedures for controlling heat stress. Periodic checks should be done to make sure that workers understand and are practicing what they have been taught.

STEP 3 Acclimatize Workers

The human body needs time to adapt to working in the heat. This adaptation cannot be rushed. It usually takes about seven days, working in a warm or hot environment for at least 100 minutes a day, to approach full acclimatization to that environment. Full acclimatization is achieved after about two weeks. Table 4 on page 12 gives a summary of acclimatization procedures.[40]

Full-time agricultural workers usually become naturally acclimatized to hot conditions as the weather gets warmer and usually need a formal acclimatization period only when there are sudden increases in workload, temperature, humidity, or protective gear that restricts cooling of the body. Migratory workers may need to acclimatize when they arrive in an area that is hotter or more humid than where they last worked. Workers who have just come from a similar job nearby may already be acclimatized to working in the area.

Acclimatization is a process where the body adapts to levels of work and heat, improving the stability of the circulatory system and the balance of salt in the body. Being in good physical condition is not the same as being acclimatized. It should not be assumed that workers who are physically fit are necessarily able to work in the heat easily. But workers in good physical condition become acclimatized faster than workers who are out of shape.[36]

With acclimatization, a person working in a warm or hot environment gains the benefits of smaller increases in body temperature and heart rate and of increased sweat production. Working without acclimatization greatly increases the risk of heat illness and work is done much less efficiently. Acclimatization will not reduce, and may increase, the water requirements of a worker. Even with acclimatization, workers may not necessarily work at higher temperatures and humidities as effectively as at lower temperatures and humidities, but acclimatization allows workers to work under heat stress conditions that would otherwise be intolerable or even fatal.[40]

An acclimatization period should be tailored to the type of work, the type of clothing worn, the climate, and the worker. A new worker should start working in the heat for either two 60-minute periods of light to moderate work or two 50-minute

Workers who have gradually adjusted to working in the heat have less risk of heat illness and will work more efficiently.

Acclimatization periods should be tailored to they type of work, the type of protective clothing required, the climate, and the worker.

periods of moderate to heavy work. The time of work in the heat should be gradually increased by about an hour a day until full acclimatization is approached. The level of physical activity should also increase progressively. The most noticeable changes in a person's adaptation to heat occur after the first or second day of work, but it is important to complete the full acclimatization period. During the acclimatization period, workers should be given work in cooler environments or a lighter workload for the balance of the day.

Some workers may faint during their first day, but as long as recovery is prompt, this should not present a problem. (See "Fainting or 'Heat Syncope,'" page 33.) However, if a new worker appears to be intolerant of heat and experiences excessive heat strain, consult a physician.

Once workers become adapted to working in a warm or hot environment, they remain acclimatized as long as they work at least every fourth day in that environment. Acclimatization will start to decline after four days of not working in that environment, drop significantly after a week, and be lost totally after three weeks. Workers who have been sick or who have not worked for three weeks need to go through a full acclimatization period all over again.

Workers will not be acclimatized to higher temperatures and humidities when there is an abrupt rise in temperature or when the weather changes from hot and dry to hot and humid. To become reacclimatized to the higher temperatures or humidities, workers need to work in the more severe conditions for half their usual time and increase this time by about an hour a day. (Special measures to take during heat spells are given on pages 20-21).[42]

Table 4

SUMMARY OF ACCLIMATIZATION PROCEDURES

Worker Status	Heat Condition	Procedures
Full-time	Gradually warming	None. Acclimatization usually occurs naturally. Acclimatization procedures usually needed only for sudden increases in temperature, humidity, workload, or level of protective gear. (See procedures below.)
Full-time	Sudden increase in air temperature, humidity, workload, or level of protective gear	1. Cut work in hotter conditions to ½ the usual time. For balance of day, work in cooler environment or lighten workload. 2. Increase time working in hotter conditions by an hour each day.
Newly hired, returning after not working for 3 weeks, or returning after being off sick	Warm; protective gear is worn Hot	1. *Light-to-moderate work:* Start work in the heat for minimum of two 60-minute periods each day. For balance of day, work in cooler environment or lighten workload. *Moderate-to-heavy work:* Start work in the heat for minimum of two 50-minute periods each day. For balance of day, work in cooler environment or lighten workload. 2. Increase time working in the heat gradually by 1 hour/day until full acclimatization is approached (average 5-7 days).

General principles:

- Tailor acclimatization period to the type of work, the type of clothing worn, the climate, and the worker.
- Start with a lighter workload; increase level of work gradually.
- Start with longer rest periods; decrease length gradually.
- Closely monitor workers' response to working in the heat.

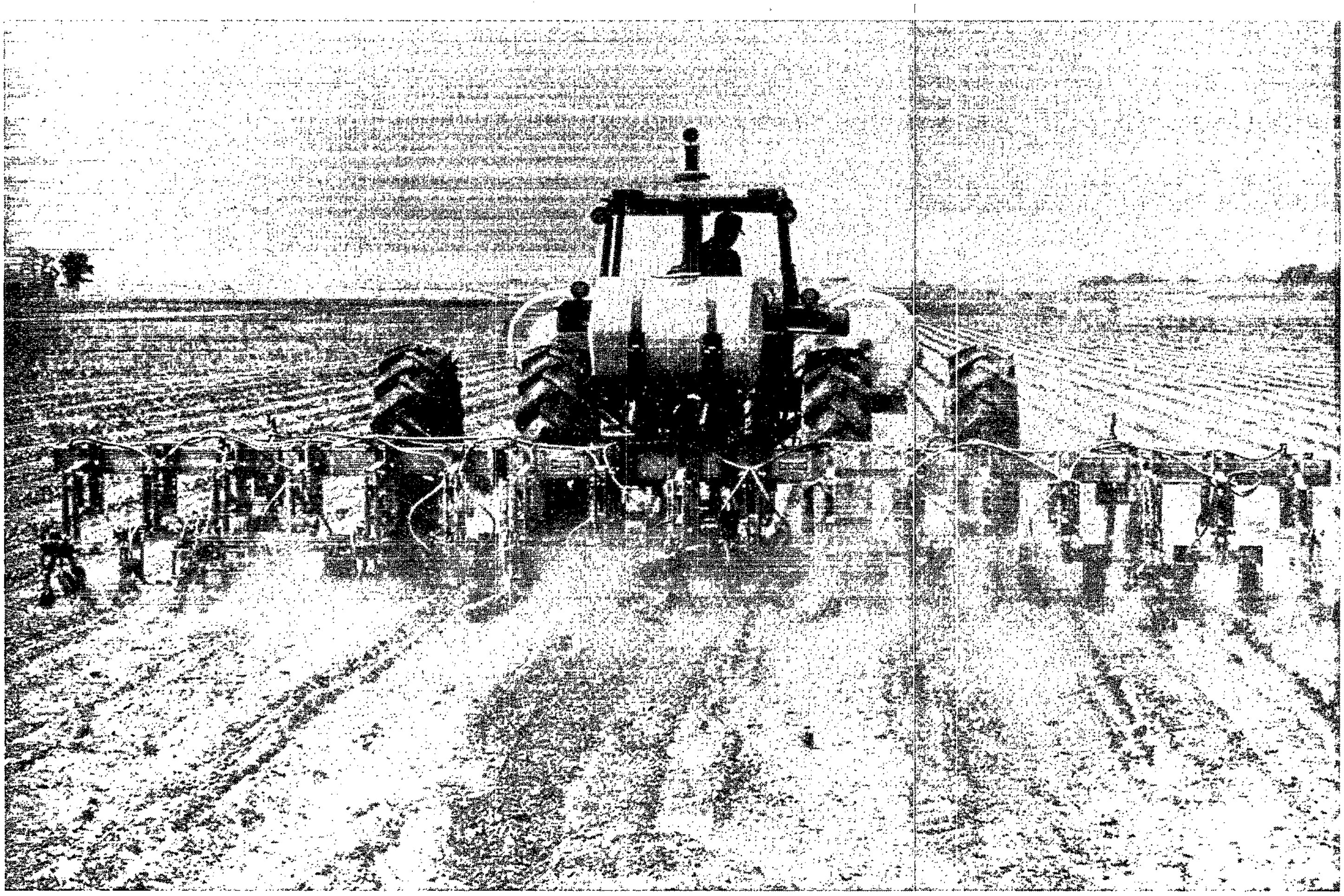
STEP 4 For Each Task, Take into Account the Conditions of Work And of the Workers

EVALUATING WORK ASSIGNMENTS

Whether a worker can perform a job safely in the heat depends on the worker's health and level of heat-acclimation, the difficulty of the job, the weather conditions on the particular day, and the kind of protective garments and equipment required. Before assigning work during warm and hot weather, take into account:

- **Weather conditions.** As the temperature and humidity increase, additional steps are needed to control heat stress, such as shortening work periods, lengthening rest periods, or reacclimatizing to the higher temperature and humidity. Further

Work assignments should take into account the weather conditions, workload, necessary protective equipment or garments, and the physical condition of the worker.



precautions are required when the sun is strong and when there is little wind or air movement. Heat exposure is most extreme in closed spaces that absorb heat from the sun and have poor ventilation, such as parked vehicles and aircraft, workshops, and storage buildings. Workers will get hotter in direct sun than under cloud cover.

Current local weather information generally is available from NOAA Weather Radio, selected state weather radio networks, cable television weather channels, and private weather information providers. Current temperature and humidity should be checked at least hourly when workers are working in hot environments. Inexpensive devices for checking humidity are available. See Appendix I for a list of suppliers of relative humidity sensors and indicator cards.

Managers should obtain a climate profile that includes seasonal temperatures and their corresponding relative humidities for work areas where their workers are exposed to heat. For help, consult the state climatologist or the National Oceanic and Atmospheric Administration Regional Climate Center. (See Appendix II.) This profile should serve as a guide for planning when to take measures to control heat stress.

■ **The workload.** Table 5 lists various tasks by the approximate workload involved. The harder the task, the more heat the body produces, the hotter a worker gets, and the more frequently rest breaks are needed. For many tasks, working faster increases the workload level.

■ **Protective garments and equipment to be worn.** Protective garments can be cumbersome and uncomfortable and make a job more difficult. Workers who wear protective garments work harder and get hotter than they would wearing regular work clothes.

Protective garments also reduce the cooling effects of sweat evaporation and of wind. Pesticide handlers can get very hot very quickly when they wear respirators, chemical-resistant suits, and rubber boots, hats, and gloves.

■ **Whether the worker is feeling well, has recently been sick, or seems to be losing weight sharply.** If a worker is losing a lot of weight over a single workday, during the

Table 5

APPROXIMATE WORKLOAD LEVELS

Light	Sitting at ease Writing, typing Sorting light materials Inspecting crops Driving mobile equipment on paved roads Piloting spray aircraft
Moderate	Using a chain saw Off-road operation of mobile equipment Periodic handling of moderately heavy materials Weeding Hoeing Picking fruits or vegetables Air blast and boom spraying Knapsack spraying on level, even ground Pushing or pulling light-weight carts or wheelbarrows Washing vehicles or aircraft Walking 2-3 mph
Heavy	Transferring heavy materials Shoveling Digging Hand mowing Loading sacks Stacking hay Planting seedlings Hand-sawing wood Pushing or pulling loaded hand carts or wheelbarrows Moving irrigation pipe Laying cinder blocks Knapsack spraying on rough ground or on an incline Walking 4 mph
Very heavy	Heavy shoveling or digging Ax work Climbing stairs, ramps, or ladders Lifting more than 44 pounds at 10 lifts per minute Walking faster than 4 mph, jogging, running

Sources: Reference 59 and EPA data.

Individual response to working in the heat can vary greatly.

work week, or from week to week, it may be due to not drinking enough water to replace body fluid lost as sweat.

■ **Whether the worker is rested, is taking any medication, or appears to have consumed alcohol that day.**

EVALUATING THE RISK OF HEAT ILLNESS

Work under hot conditions puts special stresses on the body. Even sitting and traveling in the heat for several hours inside a car without air conditioning can cause fatigue or exhaustion. People with the following characteristics are often more sensitive to heat:

- very small body size
- poor nutrition
- overweight
- poor physical condition
- lack of heat-acclimatization
- increasing age over 40
- previous heat illness (except heat cramps)
- heart disease, high blood pressure
- diabetes
- skin disease
- liver, kidney, and lung problems

Medical examinations can help identify workers with special risk of heat illness. Pre-placement and annual or more frequent followup examinations are recommended. A physician should provide a written opinion to the employer and to the worker about the worker's fitness to work in the heat. For more details about medical examinations, see Reference 5.

When working in warm and hot environments, the following factors generally increase the risk of heat illness:

■ **Environment:**

- lack of air movement
- temperatures above 70°F (80°F at night)
- direct sunlight
- humidity
- exposure to any toxic agent, including pesticides

■ **Job:**

- heavy work
- prolonged shifts

■ **Clothing and Protective Gear:**

- thicker clothing; more than one layer of clothing; tight clothing; stiff clothing; darker colors of clothing
- chemical-resistant garments and respirators

■ **Physical Condition and Personal Habits:**

- failure to drink sufficient water before work, during breaks, and after work
- lack of acclimatization
- late stages of pregnancy
- general fatigue, lack of sleep
- diarrhea, vomiting
- dehydration
- infections
- fever
- dizziness, lightheadedness
- sunburn, skin rash
- recent illness or injury
- recent immunization or inoculation
- low salt diet
- malnutrition
- sleeping pills and medications which limit sweating, such as atropine, scopolamine, antihistamines, some tranquilizers, cold medicines, some anti-diarrheal medications, and certain other medications (such as blood pressure medicine, diuretics, water pills, or amphetamines)
- use of illegal drugs
- excessive consumption of caffeine
- alcohol consumption during the previous 24 hours

Alcohol lowers tolerance of heat and increases the chances of developing heat stroke. Hangover does the same. Workers should not drink any alcoholic beverages before starting work or during the workday. [12, 30, 39, 66]

STEP 5 Manage Work Activities

Employers should include the following approaches for managing work in their heat stress control program:

- Setting up rest breaks.
- Rotating tasks.
- Shifting times for doing heavy work and work requiring protective gear.
- Reducing workloads.
- Postponing non-essential tasks.

These measures go against some traditional notions about work and productivity. But as part of an overall heat stress control program, these measures help protect employee health and help maintain worker efficiency and safety. Heat stress control programs are now standard in many industries and the armed forces.

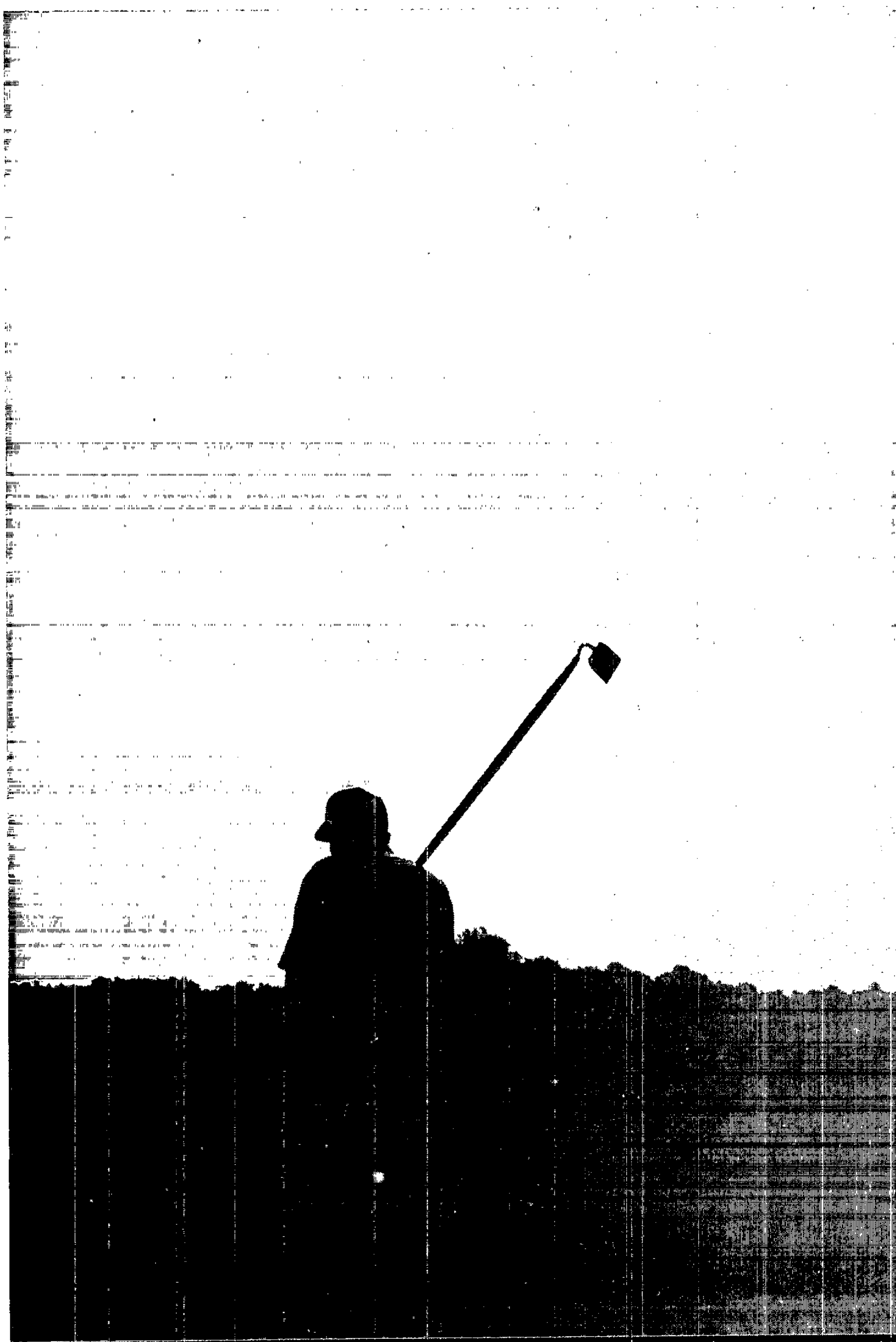
SETTING UP REST BREAKS

Workers recover from the heat more effectively with shorter, more frequent rest breaks than they do with longer, less frequent breaks. Longer, frequent rest breaks are necessary for heavier work and for work in higher temperatures and humidities. Rest breaks should be promoted among workers as a time for drinking water. Whenever possible, rest breaks should be taken in a shaded or air-conditioned area. It is hard to rest effectively in a hot environment. Rest breaks help workers recover from heat because:

- The heart rate slows.
- The body cools down.
- Body fluids lost from sweating are replaced with drinking water.

Under mild conditions, workers wearing protective gear might take a ten-minute break every hour. When heat stress conditions increase, a

(Text continues on page 20)



As heat stress conditions increase, rest breaks should become more frequent.

GENERAL PRINCIPLES FOR SETTING WORK/REST PERIODS

1 Tables 6 and 7 on pages 18 and 19 and these general principles together provide an approach for setting work/rest periods. Individual requirements may vary greatly. The work/rest periods in these tables are not a guarantee of protection against heat illness and should not be used as a substitute for good judgment and experience. These tables apply to healthy, acclimatized adults under the age of 40. They do not apply to children.

2 Managers should obtain and use Agricultural Weather Service/state climatologist climate profiles of work areas where their workers are exposed to heat as a guide for when to institute methods for controlling heat stress.

3 Trained supervisors should oversee work and rest periods and check temperature and [Table 6 only] relative humidity at least hourly when workers are working in hot environments. On a sunny day, the relative humidity will typically drop as the temperature rises. In greenhouses, higher humidities and the reduced heating effect of the sun should be accounted for when scheduling work/rest periods.

4 Shorten work periods and increase rest periods and water consumption:

- for heavier work.
- as temperature rises.
- as humidity increases [Table 6 only].
- when protective clothing or equipment is worn [Table 6 only].
- as the sun gets stronger (late morning through early afternoon).
- When there is no air movement, such as work in an enclosed space [Table 6 only].

5 Shorten work periods and increase rest periods for children and pregnant women.

6 Adjust work/rest periods to other specific conditions of work and of the workers.

7 Breaks for cooling down should not be cut short. These breaks are necessary to slow down the heart rate and cool down deep body temperature. (This is not the same as skin temperature.) Feeling cooler is not in itself a good indication that deep body temperature has dropped and that the heart rate has slowed down sufficiently.

As conditions become more severe, check the recovery heart rate after one minute of rest by counting the pulse. Place the index and middle fingers on the opposite wrist below the thumb. Count the pulse for 30 seconds. If the rate is over 55 beats (110 per minute), shorten the next work period by one-third.[19, 32, 46]

8 New and unacclimatized workers should be assigned lighter work and longer rest periods and be monitored more closely.

9 [Table 6 only] Account for weather conditions by adjusting the temperature reading as follows before going to the temperature column in the table:

- If there is full sun (no clouds) .... add 13°
  If the sky is partly cloudy/overcast .... add 7°
  If no shadows are visible or work is in the shade or at night .... *no adjustment*
- For relative humidity of:
  10% .... subtract 8°
  20% .... subtract 4°
  30% .... *no adjustment*
  40% .... add 3°
  50% .... add 6°
  60% .... add 9°

For example, if the temperature is 91°, it is dusk, the relative humidity is 40%, and heavy work is to be done, such as moving heavy materials with a wheelbarrow:

> Start with 91° and add 3° because the humidity is 40% [91°+3°=94°]. Go to 94° in the table.

Under these conditions, it would be reasonable to follow a normal work schedule.

On the other hand, if the temperature is 85°, it is midday with no clouds in the sky, the relative humidity is 50%, and heavy work is to be done, such as unloading a wagon of hay:

> Start with 85°, add 13° for the additional heating effect of the sun, and add another 6° because the humidity is 50% [85°+13°+6°=104°]. Go to 104° in the table.

Under these conditions, it might be necessary to work approximately 20 minutes and rest 40 minutes during the course of each hour that this task is done. It would be better, if circumstances permit, to shift this task to a time when it is cooler or the sun is not so strong, in order to reduce heat stress and avoid the need for longer rest periods.

APPROACHES FOR SETTING WORK/REST PERIODS

TO USE TABLE 6

You will need the following information:

- the current air temperature.
- the current relative humidity.
- an estimate of sunlight (full, partly cloudy/overcast, or no shadows visible).
- an estimate of the workload (light, moderate, or heavy). (See Table 5, page 14.)

1. Read through the general principles on page 17.

2. Adjust the current air temperature reading, if necessary, to account for the amount of sunlight and the current relative humidity (see item 9, page 17). Two examples are included with the general principles in item 9.

For work in hotter temperatures when the relative humidity is at or above 70%, use Table 7. Work under these conditions is roughly comparable to work in chemical-resistant clothing.

3. Go to Table 6, find the adjusted temperature reading, and read across to the column matching the workload. Remember that these work/rest times are only part of an overall approach and that individual requirements will vary greatly.

Table 6

APPROACH FOR SETTING WORK/REST PERIODS AND AMOUNT OF DRINKING WATER FOR WORKERS WEARING NORMAL WORK CLOTHING*

Air Temperature	Light Work	Moderate Work	Heavy Work	Minimum Water to Drink†
90	Normal	Normal	Normal	½ pint every 30 minutes
91	Normal	Normal	Normal	
92	Normal	Normal	Normal	
93	Normal	Normal	Normal	
94	Normal	Normal	Normal	
95	Normal	Normal	45/15‡	
96	Normal	Normal	45/15	
97	Normal	Normal	40/20	
98	Normal	Normal	35/25	
99	Normal	Normal	35/25	
100	Normal	45/15‡	30/30	
101	Normal	40/20	30/30	
102	Normal	35/25	25/35	
103	Normal	30/30	20/40	½ pint every 15 minutes
104	Normal	30/30	20/40	
105	Normal	25/35	15/45	
106	45/15‡	20/40	Caution‡‡	
107	40/20	15/45	Caution‡‡	½ pint every 10 minutes
108	35/25	Caution‡‡	Caution‡‡	
109	30/30	Caution‡‡	Caution‡‡	
110	15/45	Caution‡‡	Caution‡‡	
111	Caution‡‡	Caution‡‡	Caution‡‡	
112	Caution‡‡	Caution‡‡	Caution‡‡	

IMPORTANT NOTE: The general principles on page 17 must be followed when using this table. Adjustments to temperature must be made for higher humidities and heat from the sun.

*This table is based on American Conference of Governmental Industrial Hygienists limits for heat-acclimatized adults. Assumptions include physically fit, well-rested, and fully hydrated workers under the age of 40; adequate water intake; 30% relative humidity; natural ventilation with perceptible air movement; and air temperature readings in Fahrenheit, taken in the shade, no sunshine, or no shadows visible. (National Weather Service temperature readings are also taken in the shade.) See Appendix III for the method for deriving this table. Sources: ACGIH, *Threshold Limit Values*,[10,11] and NIOSH, *Occupational Exposure to Hot Environments*.[5]

†Varies from person to person and increases with heavier work and hotter conditions. At higher temperatures, there are limits to how long heavier work and consumption of large amounts of water can be kept up; continue water consumption after work to replace all lost body fluids. Source: U.S. Army, "Heat Injury Prevention." GTA 8-5-45[23]

‡45/15 minutes = 45 minutes work and 15 minutes rest during each hour.

‡‡Indicates very high levels of heat stress.

TO USE TABLE 7

You will need the following information:

- the current air temperature.
- an estimate of sunlight (full, partly cloudy/overcast, or no shadows visible).
- an estimate of the workload (light, moderate, or heavy). (See Table 5, page 14.)

1. Read through the general principles on page 17.

2. Go to Table 7, find the current air temperature, and read across to the column matching the workload and the amount of sunlight. Remember that these work/rest times are only part of an overall approach and that individual requirements will vary greatly.

Table 7

APPROACH FOR SETTING WORK/REST PERIODS AND AMOUNT OF DRINKING WATER FOR WORKERS WEARING CHEMICAL-RESISTANT SUITS*

Air Temperature	Work/Rest Periods									Minimum Water to Drink*†
	—Light Work—			—Moderate Work—			—Heavy Work—			
	Full Sun	Partly Cloudy	No Sun‡	Full Sun	Partly Cloudy	No Sun‡	Full Sun	Partly Cloudy	No Sun‡	
75°F	Normal schedule	Normal schedule	Normal schedule	Normal schedule	Normal schedule	Normal schedule	35/25‡‡	Normal schedule	Normal schedule	One half pint every 30 minutes
80°F	30/30	Normal schedule	Normal schedule	20/40	Normal schedule	Normal schedule	10/50	40/20	Normal schedule	One to 1½ pints every 30 minutes
85°F	15/45	40/20	Normal schedule	10/50	25/35	Normal schedule	Caution**	15/45	40/20	One pint or more every 15 minutes
90°F	Caution**	15/45	40/20	Caution**	Caution**	25/35	Stop work	Caution**	15/45	Same as above
95°F	Stop work	Stop work	15/45	Stop work	Stop work	Stop work	Stop work	Stop work	Stop work	Same as above

IMPORTANT NOTE: The general principles on page 17 must be followed when using this table.

*This table is based on values for heat-acclimatized adult workers under the age of 40 who are physically fit, well-rested, and fully hydrated; with the assumpations of tyvek coveralls, gloves, boots, and a respirator being worn; adequate water intake; and air temperature readings taken in the shade. Cooling vests may enable workers to work for longer periods. Adjustments must be made when additional protective gear is worn. See Appendix III for the method for deriving this table.

†Varies from person to person and increases with heavier work and hotter conditions. At higher temperatures, there are limits to how long heavier work and consumption of large amounts of water can be kept up; continue water consumption after work to replace all lost body fluids.

‡No shadows are visible or work is in the shade or at night.

‡‡35/25 = 35 minutes work and 25 minutes rest each hour.

**Indicates very high levels of heat stress.

Source: Ralph F. Goldman, *Internal Report: Heat Stress Management Protocol*, Office of Research and Development, U.S. EPA, November 1989.[7]

Tables 6 and 7 are methods for approximating a technical index called Wet Bulb Globe Temperature (WBGT), which combines the effects of humidity, air movement, air temperature, and radiation, such as sunshine. These tables are for use where instruments which measure WBGT are unavailable. Some of the work/rest times in Table 6 for hot/dry conditions may be conservative, due to approximation of WBGT. While Tables 6 and 7 allow 13° for the full heating effect of the sun (source: Reference 46), the effect of solar heat can be greater under some conditions. Table 6 is based in part on there being perceptible air movement. Where there is little or no air movement, Table 6 is not appropriate. WBGT is the heat stress index recommended by the American Conference of Governmental Industrial Hygienists, the American Industrial Hygiene Association, the American College of Sports Medicine, the International Organization for Standardization, and the National Institute for Occupational Safety and Health (NIOSH). For specific limits recommended by NIOSH for heat stress exposure for heat-acclimatized workers, see Appendix III, Table B.

Do not allow workers to push themselves or to be pushed to keep on working when they begin to feel ill from the heat. Supervisors should insist that workers take the time necessary to cool down.

(Continued from page 16)
five-minute break every half hour would be better. When workers work in chemical-resistant suits and/or in higher temperatures and humidities, the length of rest breaks and the amount of water they drink must increase sharply.[48] (See Tables 6 and 7 and "general principles" on pages 17 to 19 and Step 6 on page 22.) For situations where taking off protective gear and putting it back on may increase exposure of workers to pesticides, cooling garments can reduce the need for breaks. (See pages 26-27.)

Work/rest cycles should be flexible. Even among acclimatized workers, there are large individual differences in work capacity and tolerance to heat and this tolerance can vary from day to day.[36] Many persons are able to work under hot conditions for longer periods than those given in Tables 6 and 7; for others, these work periods may be too long.

It is more important that supervisors understand the trends and underlying principles of these tables than that they follow work/rest times exactly. The first "general principle" on page 17 is especially important and merits stating here as well:

The suggested work/rest periods in these tables are not a guarantee of protection against heat illness and should not be used as a substitute for good judgment and experience.

People naturally want to persevere and finish a task at hand. In agriculture in particular, the demands of crop production and pest control during warm and hot weather create pressure to get as much done in as short a period as possible. In addition, workers and employers often face strong economic pressure not to interrupt work.

Do not allow workers to push themselves or to be pushed to keep on working when they begin to feel ill from the heat. Supervisors should insist that workers take the time necessary to cool down. Under extreme circumstances, it may be necessary to stop work altogether, unless cooling garments are used.

"Toughing it out" is dangerous. Workers are in danger of becoming seriously ill or dying when either they or their supervisors fail to recognize the need for breaks to cool off under heat stress conditions. With heat exhaustion and heat stroke, the flow of blood to the brain decreases and mental function becomes impaired. A worker will become less aware of his or her condition and may become aggressive, try to work harder, and resist being told to stop work. There have been fatalities where workers pushed themselves harder at the very time they should have been forcibly stopped from continuing to work.

ROTATING TASKS

When possible, rotate heavier tasks among workers in the best physical condition and alternate heavy work with light and medium work.

SHIFTING TIMES FOR CERTAIN ACTIVITIES

When possible, schedule heavy tasks and work requiring protective gear for cooler hours of the day, such as in the early morning or at night, but be aware that cooler, early morning temperatures can mislead some workers to think that heat stress will not occur under these conditions. The relative humidity is usually highest at this time. Very high humidity limits evaporation of sweat, even at cooler temperatures. This can prevent adequate cooling of the body and lead to serious heat illness. When the relative humidity is above 70%, heavy work can be particularly risky. Workers should still be alert to heat strain, take rest breaks to cool down, and drink enough water to replace body fluid lost from perspiration.[12]

POSTPONING NON-ESSENTIAL TASKS DURING HEAT SPELLS

With unusually hot weather lasting longer than two days, heat can build up in the environment both at work and at home, and the body can become progressively dehydrated. Chronic dehydration can occur without any signs of thirst; in its early stages it may be indicated by a lack of alertness. During heat spells, increase water consumption both on and off the job and postpone non-essential tasks likely to cause severe heat strain until after the heat spell is over. For tasks which cannot be postponed, special measures should be taken, such as:

- Establishing sharply limited work periods.
- Restricting overtime work.
- Monitoring workers closely for heat stress.
- Wearing cooling garments. (See Step 7, page 26.)
- Assigning heavy tasks only to workers who are in good condition and are fully acclimatized.
- Conducting safety meetings to emphasize special heat spell procedures.

CHILDREN

Special efforts should be made, through training and supervision, to protect children working in hot environments. When doing similar work in hot environments, pre-adolescent children generate more heat for their body weight than adults and, at the same time, their bodies do not sweat as much. As a result, children tend not to cool off as quickly and have a lower tolerance for work in very high temperatures.[76]

During heat spells, special measures should be taken, such as postponing non-essential tasks and monitoring workers closely for heat stress.

Child workers need to take longer rest breaks, work fewer hours per day, work fewer days per week, and be strongly directed to drink adequate amounts of fluid. Children should be given extra supervision because their judgment is different from that of adults. Child workers also should be strongly encouraged to be alert to symptoms of heat illness in themselves and not to take risks.[15, 16, 21, 25, 56, 65]

STEP 6 Establish A Drinking Water Program

DEHYDRATION

Dehydration is a primary cause of heat illness. Replacing body fluid lost in sweating is the single most important way to control heat stress and prevent heat illness.

Dehydration has several notable effects:

■ **Reducing skin cooling.** The principal way the body cools itself is through the evaporation of perspiration. Dehydration results in less body water being available for sweating and reduces the body's ability to disperse heat by evaporation of sweat.

■ **Straining the circulatory system.** The body contains about five quarts of blood, composed mostly of water. When a worker starts to perspire during work in the heat, the rate of circulation increases. Blood also helps cool the body by moving heat produced by the muscles outward to the skin for release into the air.

When dehydration occurs, the blood flow needs of the skin and active muscles are not met. The

This cartoon appeared during Operation Desert Shield. Despite the humorous treatment given here, the U.S. Army viewed water to be as important as ammunition in logistics planning and as the primary tool for maintaining individual performance, health, and hygiene in the desert heat.

Under very severe heat stress conditions, a person can sweat up to two quarts per hour. Workers need to be reminded constantly of their need to drink water and be directed to drink "by the clock."

body produces less sweat and becomes overheated from work. A lack of alertness may indicate early stages of dehydration. Additional effects of dehydration include muscle exhaustion, lower performance, clumsiness, dehydration of body tissue, and less blood being pumped by the heart with each beat. Severe dehydration can result in death.

DRINKING WATER AND FLUID REPLACEMENT

The amount of drinking water necessary to replace water lost as sweat and prevent dehydration varies with each person and is affected by temperature, humidity, and work being done. The idea that a person can become like a camel and adjust to working in the heat with less water is strictly a myth. Estimates of water requirements for persons doing moderate work in temperate regions during the summer range from **six to ten quarts per person** per day. On a hot day, it is possible for a worker to lose as much as three gallons of perspiration. At low humidities, a person can be sweating heavily and still have dry skin. Most protective garments limit sweat evaporation (but not sweat production) and chemical-resistant suits can cause rapid dehydration if sweat is not replaced. Under very severe heat stress conditions, a person can sweat up to two quarts per hour, but this rate of sweating cannot be tolerated for long.

As a general principle, workers should drink enough water to replace all body fluid lost through perspiration. Put another way, workers should drink enough water to maintain their normal body weight throughout the day. A sharp loss in weight is an indication that a worker has not been drinking enough water. Other indications are dark yellow urine and passing less urine than usual. Having workers weigh in each morning on a bathroom scale is a simple way to check for a sharp loss in weight.

Workers need to be reminded constantly of their need to drink water. When they are very busy, they will be prone to drink even less. **Thirst is not a good way to know how much water a person needs to drink, nor is satisfaction of thirst an indication that body fluids have been replaced.** Workers who have plenty of drinking water available but only drink to satisfy their thirst will drink about two-thirds the amount of water their bodies need. This can result in a net loss of one to two quarts of body fluid (two to four pounds of body weight) on a hot day. Chronic dehydration can develop gradually over several days and occur without any signs of thirst. It can lead to severe medical problems, such as constipation, piles, kidney stones, and urinary infections.[76]

In general, when workers work in hot environments, they should be directed to drink "by the clock," at least one cup of water every 30 minutes and greater amounts as conditions become more extreme, even if they are not thirsty. It is easier to drink smaller amounts of water frequently than it is to drink larger amounts less often. Drinking two or three cups of water before work gives a head start. Experienced, acclimatized workers and supervisors who have not previously followed a rigorous drinking water schedule may be surprised at the reduction of strain from the heat.[75]

Under severe heat stress conditions, such as heavy work in high temperatures or work in encapsulating clothing at temperatures above 70°F, workers should be scheduled and directed to drink a pint or more of water before starting work and enough additional water throughout the day to replace all sweat lost. They should also be encouraged to drink ample quantities of water after work, through the end of the evening meal.

Caution: Persons with epilepsy or with heart, kidney, or liver disease; persons who have fluid-retention problems; and persons who are on restricted fluids should consult a physician before increasing the amount of fluid they drink.[20]

Supervisors should be alert to workers who, because of economic pressure, deliberately limit the amount of water they drink in order not to have to stop work to urinate. Older men with prostate problems and some women may also limit the amount of water they drink when a private toilet is not readily available. Where these problems occur, employers need to address these concerns to make sure that these workers will drink enough water. Under hot conditions, drinking a lot of water does not cause an increase in urine, provided that excessive caffeine has not been consumed.

Supervisors should remind workers that not drinking enough water can lead to heat exhaustion and heat stroke and that avoiding urinating can lead to other severe medical problems. Supervisors should also stress how drinking ample water helps one to stay productive and maintain well-being in the heat.

Preferable water temperature is between 50° and 60°F. Most people tend not to drink warm or very cold water in quanity as readily as they will cool water.

OSHA's Field Sanitation Standard* sets minimum requirements for drinking water, which should be followed throughout agriculture. OSHA requirements include:

- **Providing sufficient amounts of suitably cool, potable water.** On average, a total of two to three gallons per worker on a hot day should be enough, but specific needs will vary. Preferable water temperature is between 50° to 60°F. Most people tend not to drink warm or very cold water in quantity as readily as they will cool water.

- **Providing single-use drinking cups or water fountains.** Individual canteens or sport bottles may be more suitable for some situations. The use of common drinking cups or dippers is prohibited. People tend to drink more water from cups and containers than they do from water fountains.

- **Providing water that meets water quality standards.** Water must meet either state standards, local standards, or standards under the U.S. EPA's "National Interim Primary Drinking Water Regulations"**

- **Placing water in locations readily accessible to all employees.** Drinking water should be located as close as possible to where workers are working (but protected from contamination by pesticides) so it can be drunk whenever it is needed.[55]

Workers should be directed only to drink safe drinking water. Some workers believe that they can drink irrigation water and need to be told that irrigation water can contain pesticides and fertilizers.[73]

SOFT DRINKS

Flavored beverages are desirable if workers will drink them in large quantities. Avoid beverages high in sugar or salt content. Carbonated soft drinks are not recommended as a primary beverage for replacing body fluid because the gas makes them difficult to drink in large quantities. Dilute iced tea or lemonade are good alternatives if the sugar content is kept low. Unfortunately, drinks which "cut" thirst also discourage adequate fluid replacement.[29, 55, 69]

ALCOHOL

Drinking alcohol while working in the heat should be prohibited. Alcohol affects the body's temperature-regulating capacities and increases the risk of heat illness. Every heat stress training program should emphasize the hazards caused by alcohol. Workers should be strongly urged not to drink any alcohol during hot weather before starting work and until the end of the evening

* 29 Code of Federal Regulations 1928.110

** 40 Code of Federal Regulations 141

meal after work in order to give their body a chance for full replacement of all lost fluid.

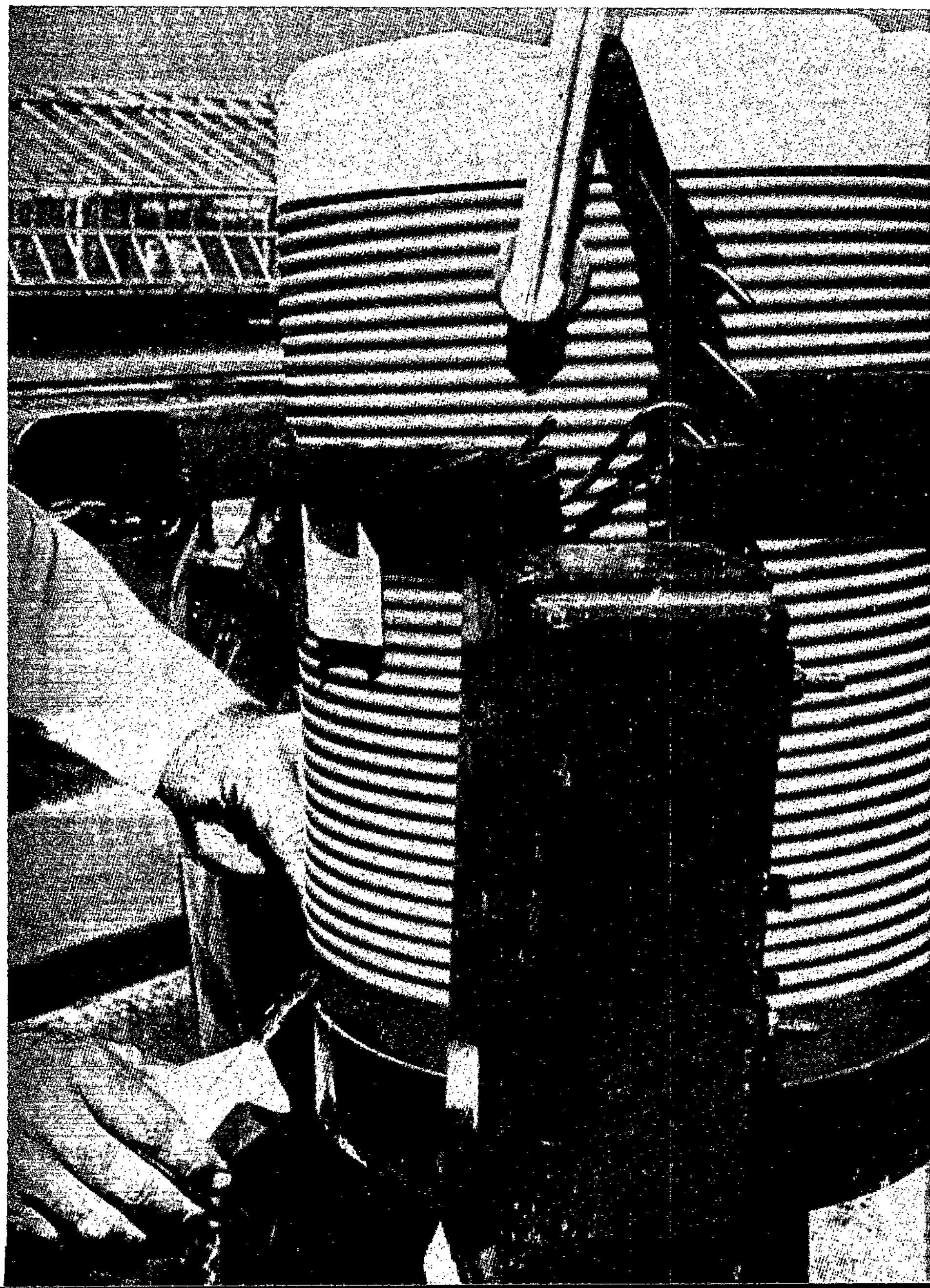
SALT AND OTHER ELECTROLYTES

A balanced diet usually contains enough salt, even during the hottest weather. If a worker's diet is lacking salt, consult a physician about what to do. Routine addition of salt can lead to dehydration. A heavy salt diet may interfere with acclimatization and contribute to heat illness.[36]

Salt tablets should not be used. Persons who have heart problems or who are on a "low salt" diet should consult a physician about their working under heat stress conditions.

Heavy work in the heat can lead to a loss of glycogen (a type of carbohydrate) from the liver and muscles and a loss of electrolytes, in addition to a loss of water in the body. Some scientists believe that electrolyte-carbohydrate beverages may be of benefit when workers do heavy work in the heat for more than one hour. Commercial electrolyte-carbohydrate products are not all formulated identically. Some ready-to-drink formulations are too concentrated and need to be diluted. Some contain too much sugar. Employers electing to provide these beverages should ask suppliers for electrolyte-carbohydrate products that have a content similar to what the Food and Nutrition Board of the National Academy of Sciences Committee on Military Nutrition Research recommends* and that their workers find tasty.[76]

* **Technical Note:** While the use and formulation of these products bear further evaluation, the Food and Nutrition Board of the National Academy of Sciences Committee on Military Nutrition Research has recommended that these "solutions should provide approximately 20 to 30 meq [milli-equivalents] of sodium per liter, 2 to 5 meq of potassium per liter, and chloride as the only anion. The carbohydrate content should be provided as glucose or sucrose malto-dextrin, or other complex carbohydrate in a concentration of 5% to 10%."[31]



Drinking water must be readily accessible.

STEP 7 Take Additional Measures

PROBLEMS FROM PROTECTIVE GARMENTS

Pesticide handlers and "early entry" workers are required to wear protective gear for many pesticides. This can present a conflict between protection against pesticide exposure and avoiding heat stress. The very weight of some garments and respirators can increase the amount of heat the body produces.

SPECIAL COOLING GARMENTS

One way to slow the buildup of heat when wearing protective gear is to use special cooling garments, such as cooling vests, which are also known as "ice" vests.[13,24,33,70] Cooling garments:

■ Let workers work harder, longer, and more comfortably in the heat.

■ Lower skin temperature.

■ Reduce the risk of body dehydration.

■ Reduce the need for frequent water breaks.

■ Reduce the frequency that protective gear needs to be taken off.

Cooling vests have the disadvantages of extra bulk and weight, limited time of use, and the need to store coolant packets. Nevertheless, cooling vests are one of the most effective ways for workers, especially pesticide handlers and early entry workers who wear chemical-resistant suits, to work comfortably and productively in the heat with reduced heat stress. Cooling vests are now used extensively in the nuclear power, chemical, and steel industries and in space exploration.

Care should be taken to avoid too much cooling. Effects can include reddening of the skin. When

workers are hot and sweaty, cooling vests may feel uncomfortable when they are first put on.[14]

Some vests are too cold to wear directly against the skin. While one or two layers of clothing worn underneath the vest should take care of this, pilots and mobile equipment operators may need to wear three layers because of the cold pressure against their back from the back of the seat.[14]

Persons with a short trunk of the body may need to remove the bottom row of coolant packets to make it easier to bend over.[14]

COOLING VESTS AND CHEMICAL-RESISTANT SUITS

Workers will not want to wear cooling vests unless working without them is uncomfortable or intolerable.

■ **Below 70°F.** Workers should not need cooling vests unless they are doing heavy, sustained work.

■ **Above 70°F.** Cooling vests may be useful when pesticide handlers are wearing chemical-resistant suits and are either doing heavy work or doing moderate work for a prolonged period.

■ **Above 80°F.** Working in chemical-resistant suits for more than a half hour without taking frequent water and rest breaks is unsafe. Special measures, such as wearing cooling garments, are recommended and workers should take frequent breaks. (See Table 7, page 19.)

The effectiveness of cooling vests drops as their coolant packets become warmer. Workers wearing cooling vests should take rest breaks combined with scheduled water breaks when the coolant packets need changing. There is danger of contaminating the skin each time a protective garment contaminated with pesticides is opened and closed or taken off and put back on. The longer a worker can work safely in a protective garment before needing relief from the heat, the safer overall the worker will be.

Roofs can shade pesticide mixing stations.

SELECTING COOLING VESTS

Cooling vests should be selected with care. Recommended features include:

- Snug fit, hanging from the shoulders and extending below the waist to hip level.
- Effective exterior insulation.
- Comfortable fabric with good water absorption and retention, such as cotton.
- Flexibility and minimum bulk for easy movement.

These features maximize contact between the trunk of the body and the vest, provide greater cooling, and minimize interaction of the trunk of the body and coolant packets with environmental heat. See Appendix I for a list of suppliers of cooling garments.

MAINTAINING COOLING VESTS

Vests should be washed frequently to remove body odor — daily if more than one worker uses the same vest or if the vest is worn under protective garments for handling pesticides. Coolant packets should be discarded when their seams open or they are punctured.

OTHER COOLING GARMENTS

Cooling systems which deliver cool air or pump ice water to special garments worn by a worker may be useful in some situations. For a list of suppliers of these systems, see Appendix I.

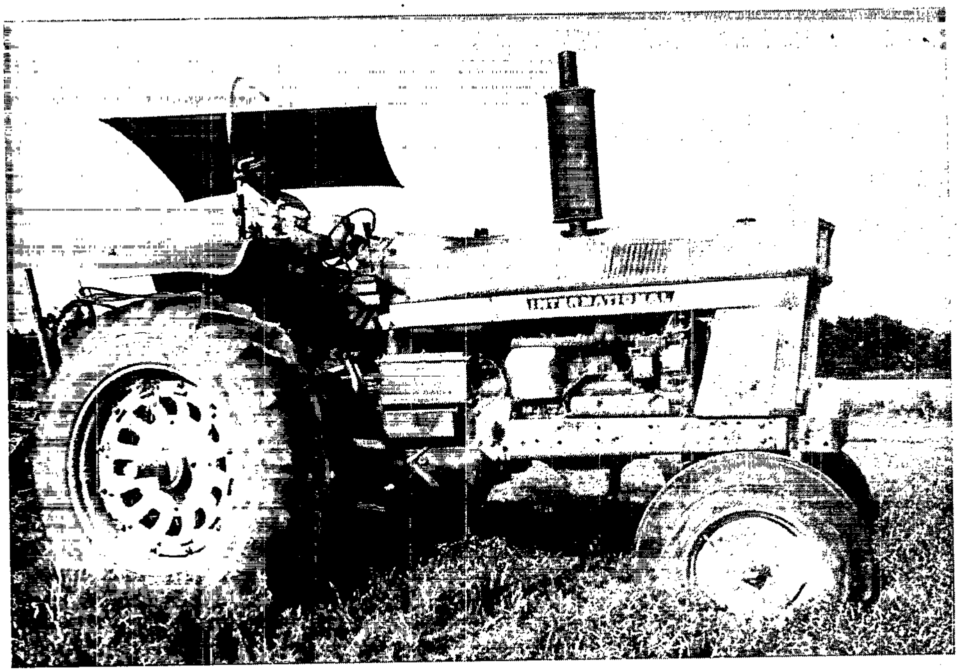
SELECT LIGHTER WEIGHT PROTECTIVE GEAR AND COOLER RESPIRATORS

Wearing lighter weight clothing and gear reduces the amount of heat the body produces. Light color clothing absorbs less heat from the sun than darker clothing. Whenever possible, use the lightest weight protective garments and respirators that give adequate protection.

Powered air-purifying respirators and supplied-air respirators generally feel cooler than other types of respirators because breathing resist-

Brimmed hats help shade the head and eyes.

Awnings provide shade over open mobile equipment.



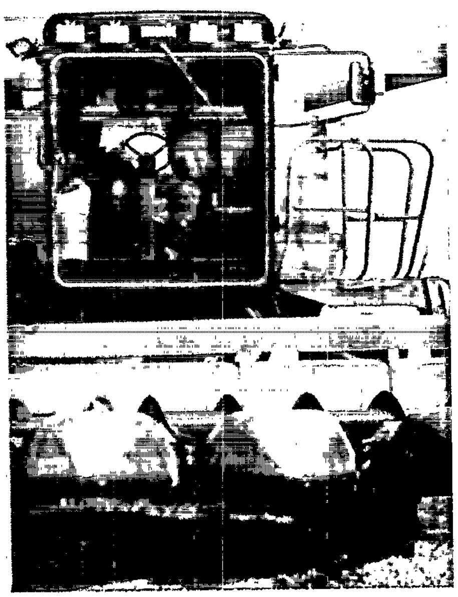
ance is minimized and the airstream has a cooling effect.

SHADE

Shade gives relief from the heat of the sun. Canopies, sunshades, and umbrellas can provide shade to open mobile equipment. Canopies are also helpful over pesticide mixing stations. The benefits of wearing brimmed hats and sunglasses for shading the head and eyes should also not be overlooked. Whenever possible, workers should spend rest periods in a shaded area not contaminated with pesticides. With open field conditions, tarpaulins tied to four posts can provide shade where no other shade is available.

AIR-CONDITIONED CABS ON MOBILE EQUIPMENT

Enclosed air-conditioned cabs on mobile equipment reduce exposure to heat, the need for protective gear, and pesticide exposure to an applicator. Air conditioning filtration systems should be appropriate for the pesticides used.



Air-conditioned cabs on mobile equipment reduce exposure to heat and pesticides.

MODIFYING PESTICIDE USAGE AND HANDLING

Under many circumstances, growers can consider modifying growing practices and use integrated pest management programs to reduce or eliminate the need for highly toxic pesticides which require protective garments and respirators. Even where growing practices are not modified, applicators may be able to substitute pesticides of lower toxicity for those which require protective gear. Totally closed pesticide mixing systems can also reduce the need for protective gear. Technical help on growing practices and selection of pesticides can be obtained from cooperative extension services.

PROTECTING PILOTS

The risk of heat strain among agricultural pilots is particularly high because cockpits become heated in the sun, even during moderate weather, creating what has been called a "greenhouse effect." Inside cockpit temperatures can rise well above the outside air temperature. Some levels of heat stress normally endured by ground workers can be dangerous in pilots. Even subtle changes in psychomotor performance and neurobehavioral function caused by mild heat strain affect a pilot's judgment and ability to fly safely. Fatigue is a basic concern with pilot safety and is compounded with exposure to heat. Heat and dehydration also lower pilot tolerance of acceleration (G) stress.[18, 34, 47, 48, 49, 50, 52, 53, 54, 63, 73]

Agricultural pilots are subject to additional hazards beyond those faced by ground workers. Low-level flying demands that pilots devote their maximum concentration to conditions outside the cockpit. They often fly near telephone and power lines and poles, and make scores of 180° turns each day.[34, 62]

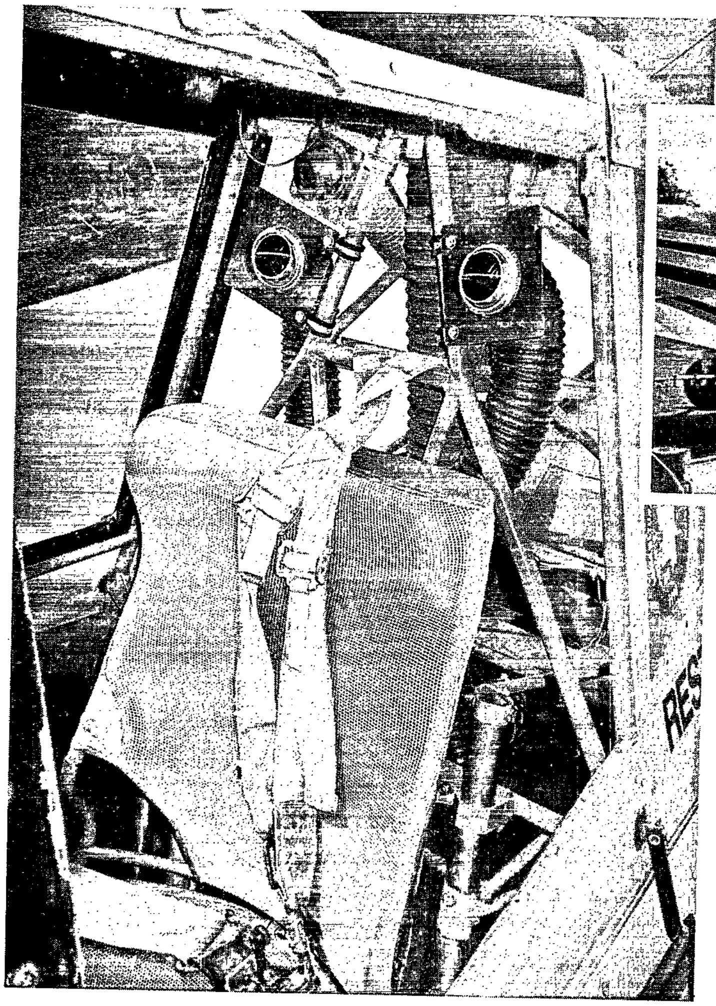
Heat and sweat — especially sweat dripping from the forehead into the eyes which can cause the eyes to have painful spasms — are uncomfortable and distracting, and decrease pilot alertness. Sweatbands are helpful for keeping sweat out of the eyes.[51]

Minor effects from even very low exposures to certain classes of pesticides, such as organophosphates and carbamates, can also result in impaired judgment in flying and play a role in agricultural aircraft accidents. The interaction of mild heat strain and low-level exposures to pesticides may be even more detrimental to pilot safety. People are often unaware of these minor effects, making this danger worse.[22, 26, 48, 52, 61, 62, 63, 64, 68]

It is essential for safe aircraft operation that pilots fly at peak efficiency. Heat stress problems in agricultural aviation are similar to those with military aircraft flying at low altitudes. The Indexes of Thermal Stress for Hot Weather Aircraft Operation are used in military aviation and may be useful in agricultural aviation. (Tables 8 and 9 on page 31.) Pilots should avoid heat stress from exposure to heat before and between flights and from physical exertion.[50]

In aircraft without air conditioning, there should be a thermometer placed out of direct sun for measuring inside cockpit temperature. At the present time, probably the most effective ways to counter hot cockpit conditions in places where there are long, sustained periods of heat are to wear cooling garments and fly during hours when the sun is not strong or, where possible, to install air conditioning if the cockpit is closed. The air conditioning system should be of a design that prevents pilot contamination.

Cockpit air conditioning systems present a tradeoff in how horsepower is used: the benefits include improved pilot comfort, productivity, and safety, and a lessened risk of heat strain and fatigue; drawbacks may include reduced payload.



Cockpit air conditioning improves pilot comfort, productivity, and safety.

INDEXES OF THERMAL STRESS FOR HOT WEATHER AIRCRAFT OPERATION

The following tables were derived from the U.S. Air Force's Fighter Index of Thermal Stress.[53,71]* The Fighter Index of Thermal Stress was developed to indicate hot conditions which can impair mental performance of flight crews. Air Force flight crews are assumed to be above average in physical fitness. Age and other differences from assumed characteristics for Air Force flight crews may require greater caution for individual agricultural pilots.

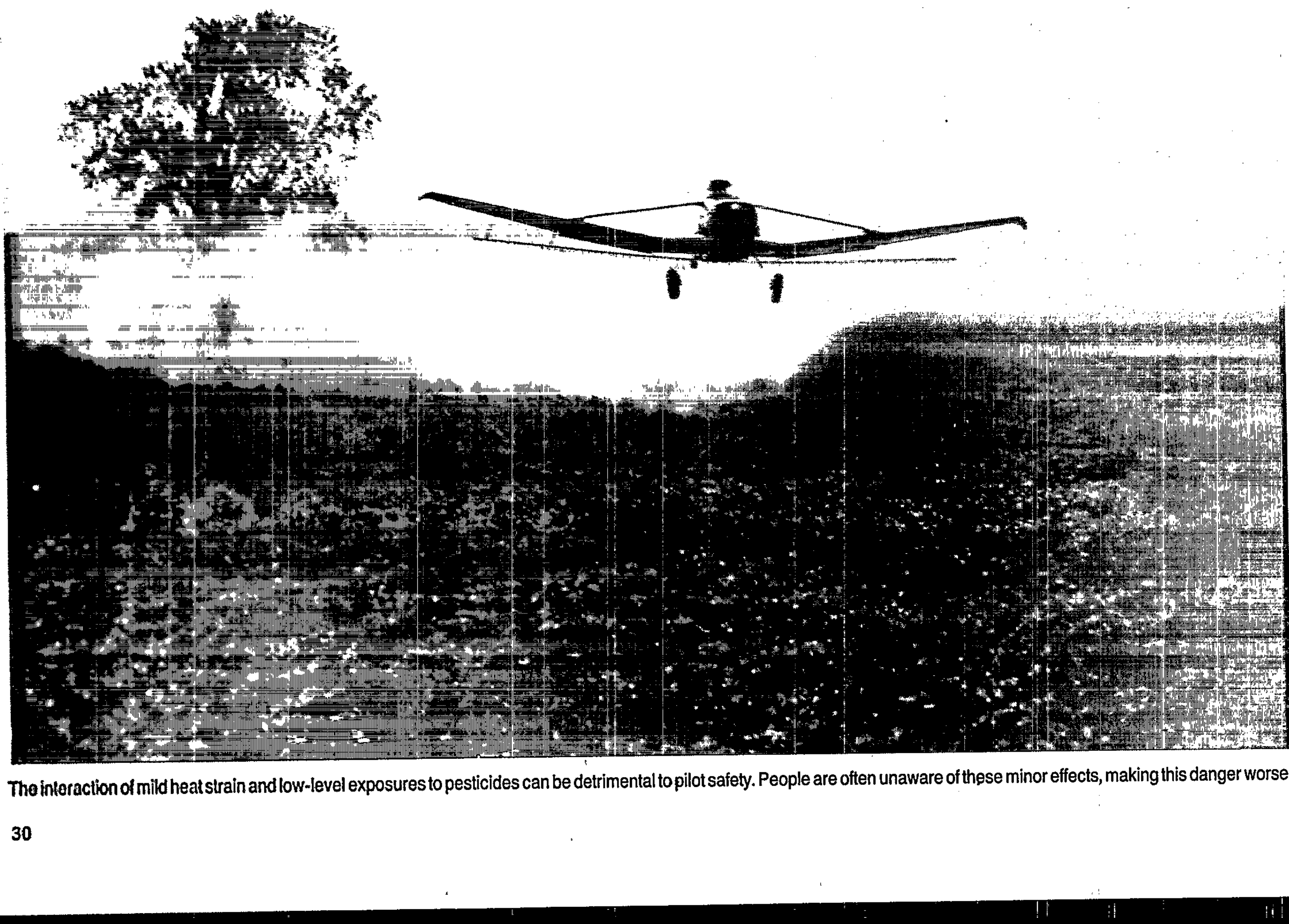
These tables account for heat exposure during flight and time on the ground, using ground weather measurements (shaded air temperature and relative humidity).

Assumptions include:

- Pilot is fully acclimatized to the heat.
- Pilot begins work well-hydrated and reasonably rested.
- Adequate fluid intake is maintained. (See Step 6, pages 22-25.)
- Pilot performs no mixing, loading, or other moderate to heavy work.
- Pilot has no pesticide exposure.
- Summer flight clothing is worn. These tables do not account for protective garments.

Users should recognize the limitations of these tables. The exposure limits do not account for individual variations in cockpit cooling capacity or human heat susceptibility.

*Appendix IV contains a more detailed discussion of the Fighter Index.



The interaction of mild heat strain and low-level exposures to pesticides can be detrimental to pilot safety. People are often unaware of these minor effects, making this danger worse.

Table 8

INDEX OF THERMAL STRESS FOR HOT WEATHER AIRCRAFT OPERATION (DIRECT SUN)

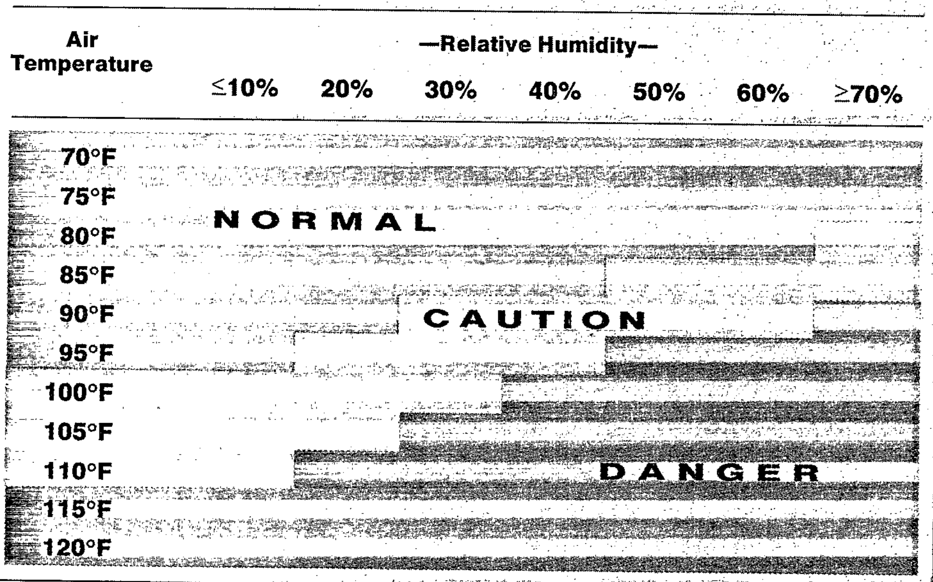
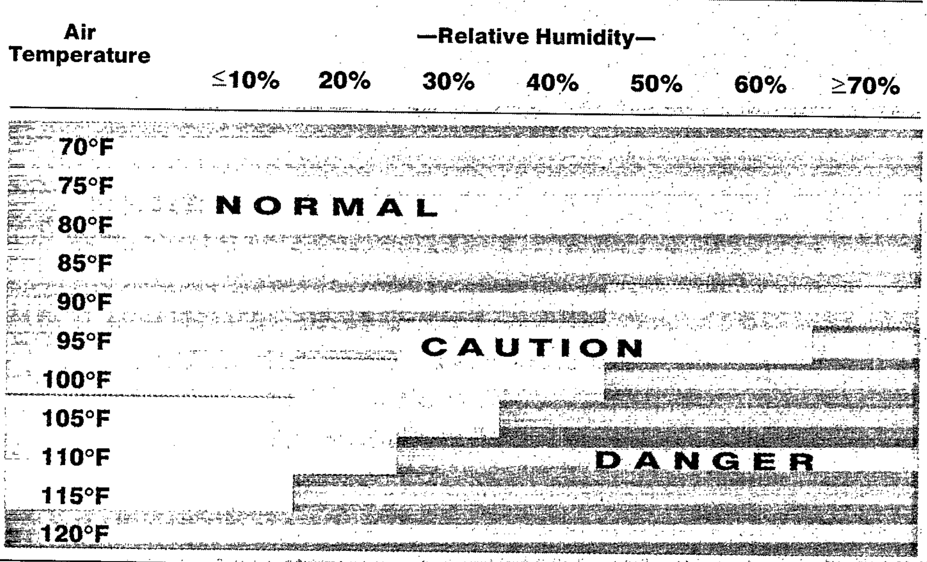


Table 9

INDEX OF THERMAL STRESS FOR HOT WEATHER AIRCRAFT OPERATION (MODERATE OVERCAST SKY)



- **Normal zone** covers conditions which feelhot but are usually safe if reasonable precautions are followed. Do not push activities during the first hot days of summer.

- **Caution zone** includes conditions which are tolerable if adequate precautions are taken. Effects on the body are small, but subtle impairments of mental performance can occur, including altered learning curves, shortened time sense, impaired vigilance, and increased error rates on tracking tasks. Even under ideal conditions, internal body temperature remains high for one hour after heat exposure, although a pilot will feel comfortable in a cooler environment within a few minutes.
  - Be aware of heat stress.
  - Cool off between flights if cockpit is not air conditioned.
  - Limit exposure to heat on the gound to a total of 90 minutes, unless pilot has had complete rehydration and recovery from the heat.

- **Danger zone** covers conditions where human defenses are inadequate. Heat buildup in the body and dehydration increase with the severity of conditions. Associated effects include marked decreases in acceleration tolerance, marked decreases in mental performance, such as poor response to unexpected events, and failure of the body's temperature regulating system, with increasing likelihood of physical collapse.
  - Postponement of work is recommended if cockpit is not air conditioned.
  - Limit exposure to heat on the ground to a total of 45 minutes, unless pilot has had complete rehydration and recovery from the heat.

STEP 8 Give First Aid When Workers Become Ill

SETTING UP A FIRST AID PROGRAM

When workers become ill from the heat, immediate response with the right procedures can stop them from getting worse. A good first aid program prepares the way for people to respond on the spot, without having to guess what to do and scramble for help.

Preparations for first aid should include:

■ **Designating a person responsible on-site** for resolving questions about how to handle suspected cases of heat stroke. This person should have training and experience with heat illness and be able to take charge, make decisions, give directions to others, stay with a sick worker until the problem is resolved, and report on the problem to medical personnel and, at larger establishments, to higher management.

■ **Establishing a line of authority.** At larger establishments, the person responsible for dealing with heat stress problems on-site should document and report all incidents of heat illness to the person who has principal responsibility for managing the heat stress program. This gives an employer needed information for handling heat stress situations.

■ **Training workers and supervisors to treat heat illnesses,** including first aid procedures and procedures for getting emergency medical help.

■ **Maintaining first aid supplies on-site.** Supplies should include water, a piece of material, such as a bath towel for a large piece of cardboard, for fanning a heat stroke victim, and a cotton sheet to soak in water and wrap around a heat stroke victim. These supplies should be protected against contamination from pesticides.

■ **Arranging for emergency care** with a nearby medical facility and **setting up emergency transportation.** The name, address, and telephone number of the medical facility; travel directions; and information about emergency transportation should be posted at the telephone at a central location at the worksite. This information should also be included in worker and supervisor training. Commercial pesticide applicators should carry information about emergency care and transportation with them to each job site.

RECOGNITION OF HEAT ILLNESS

Workers should not work alone in the heat for long periods of time. Workers who are trained and experienced should be able to recognize early signs of overheating in themselves, but it should not be assumed that they will always do so or will always respond appropriately. Either first line supervisors should watch workers closely or a "buddy" rule should be established for workers to watch each other, so that a worker who becomes ill will be noticed and given first aid promptly. When one worker becomes ill from the heat, supervisors should take this as a warning that other workers may also be at immediate risk and may need to cool down and drink more fluids.

GENERAL PRINCIPLES

Step-by-step measures for treating heat illnesses are given in Table 1 on page 4. The following measures apply across the board:

■ All persons should avoid direct contact with clothing heavily contaminated with pesticides.

■ Protective garments should be loosened or removed only in an area where there will be no exposure to pesticides.

■ A person who develops heat illness should not do work which requires chemical-resistant suits and should avoid other work likely to cause heat stress for the rest of the day.

■ A person who collapses or faints for any reason should not be allowed to work for the rest of the day. Vital signs should be monitored and medical personnel should examine the person before the person is allowed to leave for home.

TREATING HEAT STROKE

Heat stroke is the most dangerous illness that can result from the body's overheating. When a person gets heat stroke, the blood-clotting mechanism and liver and kidney functions are often severely damaged, the lungs can accumulate fluid, the central nervous system can be damaged irreversibly, and virtually all other organs and tissues sustain injury. Heat

A good first aid program prepares people to respond to heat illness without having to guess what to do.

stroke can develop quickly without symptoms of heat exhaustion.[36]

Heat stroke is always an immediate life-threatening medical emergency. When a worker gets heat stroke, body temperature must be lowered as rapidly as possible. This is at least as, if not more, important than rushing the worker to a doctor, although the worker should be given medical attention as quickly as possible. Survival may depend on how quickly cooling is begun. If necessary, delay transporting the worker until cooling procedures procedures have been started.

To lower body temperature rapidly:

- Place the worker in the shade if possible, remove the worker's clothing and shoes, wrap the worker in the sheet from the first aid supplies, and pour water over the sheet.

- Cool the head with wet compresses.

- Fan the worker with a towel or a large piece of cardboard.

- Add water as needed to keep the sheet wet, and continue the cooling during transport to a medical facility.

When pesticide handlers and early entry workers get heat stroke:

- Do not delay initial cooling in order to do lengthy decontamination, but it is still important to avoid exposure to contamination. Decontamination by sponging with soap and water will itself help cool the body.

- Alert ambulance crews and personnel at the medical treatment facility to the possibility of pesticide contamination.

- Inform medical personnel of the product names, EPA registration numbers, and active ingredients of all pesticides to which a worker was exposed. If possible, bring the pesticide labels along.

The on-site person responsible for dealing with heat stress problems can accompany the worker to the medical facility to take care of these items.

FAINTING AND SALT DEPLETION HEAT EXHAUSTION

Fainting and salt depletion heat exhaustion are two other forms of heat illness which may occur.

- **Fainting, or "heat syncope."** Fainting not associated with heat exhaustion or heat stroke can occur when unacclimatized workers stay in one position too long without moving around or do strenuous work they are not used to doing, or when there is a sudden rise in air temperature or humidity. It is caused by blood "pooling" in the lower parts of the body and the dilated blood vessels in the skin, resulting in less blood going to the brain.[36]

Treatment includes removal to a cooler area and rest lying down. Recovery should be prompt and complete. If it is not, treat as a case of heat stroke until proven otherwise. Fainting can be prevented by acclimatization and avoiding staying too long in a stationary position.[66]

- **Salt depletion heat exhaustion.** This illness is similar to heat exhaustion arising from dehydration, except that the victim usually does not feel thirsty and usually has heat cramps and vomiting. When pesticide handlers and "early entry" workers become ill with these symptoms, pesticide poisoning must also be considered. Diagnosis and treatment of salt depletion heat exhaustion should be done by medical personnel.

FOLLOWING UP ON INCIDENTS

When a worker develops heat illness, the person who oversees the employer's heat stress program should evaluate how the incident was handled and follow up with measures necessary for improvement. A special safety meeting should be conducted with workers and supervisors to review the incident, discuss how the incident could have been prevented, and stress other key procedures for preventing heat illness.

Employers should notify appropriate government agencies about serious incidents, as required. By law, OSHA must be notified if there is a fatality or five or more workers have been hospitalized from one accident.*

*29 Code of Federal Regulations 1904.8

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APPENDIX I
Suppliers

EPA and OSHA have not evaluated the performance of these devices. These items are included for information purposes only. EPA and OSHA have made every effort to include all known suppliers and regret if there are any not listed here.

SUPPLIERS OF COOLING GARMENTS

Including Suppliers of:
- Combination Vest/Respirator Supplied Air Systems
- Whole Body Cooling Systems — Air Cooled and Water Cooled
- Cooling Vests — Ice Packs, Gel Packs, Air Pump Cooled, and Water Pump Cooled

Abanda, Inc.
401 Lee Street, N.E., Suite 400
P.O. Box 2028
Decatur, AL 35602
(800) 522-2628

GEMPLER'S, Inc.
211 Blue Mounds Rd.
P.O. Box 270
Mt. Horeb, WI 53572
(800) 382-8473

Durafab
P.O. Box 658
Cleburne, TX 76031
(800) 433-1824

Encon Safety Products
1333 Northwest Freeway (77040)
P.O. Box 3826
Houston, TX 77253
(713) 460-5816

Fyrepel Products, Inc.
951 Buckeye Avenue - Box 518
Newark, OH 43055
(614) 344-0391

ILC Dover, Inc.
P.O. Box 266
Frederica, DE 19946
(302) 335-3911

Koslow Technologies Corp.
180 Osborne Street
Bridgeport, CT 06605
(800) 332-0306

Life Support Systems, Inc.
1400 North Shoreline Boulevard
Mountain View, CA 94043
(800) 878-5774

MSA
36 Great Valley Parkway
Malvern, PA 19355
(800) 657-2222

Racal Health and Safety, Inc.
7305 Executive Way
Frederick, MD 21701
(800) 682-9500

Steele Incorporated
First and Washington
P.O. Box 7304
Kingston, WA 98346
(206) 297-4555

Trusafe
9369 8th Avenue South
Seattle, WA 98108
(206) 762-7407

Vortec Corporation
10125 Carver Road
Cincinnati, OH 45242-9976
(800) 441-7475

Wheeler Protective Apparel, Inc.
4330 West Belmont Avenue
Chicago, IL 60641-4581
(800) 542-1152

SUPPLIERS OF SELECTED DEVICES FOR EVALUATING HEAT STRESS AND HEAT STRESS CONDITIONS

Including Suppliers of:
- Personal Temperature Monitors (PTM)
- Relative Humidity Sensors (RHS) and Indicator Cards (RHIC)
- Wet Bulb Globe Temperature Monitors (WBGT)

Airflow Technical Products, Inc.
P.O. Box M552
Landing, NJ 07850
(800) 247-8887 **RHS**

Bacharach, Inc.
625 Alpha Drive
Pittsburgh, PA 15238
(412) 963-2000 **RHS**

Brooklyn Thermometer Company, Inc.
90 Verdi Street
Farmingdale, NY 11735
(516) 694-7610 **RHS**

Bruel & Kjær
185 Forest Street
Marlborough, MA 01752
(508) 481-7000 **WBGT**

Davis Instrument Manufacturing Co., Inc.
Seton Business Center
4701 Mt. Hope Drive
Baltimore, MD 21215
(800) 368-2516 **RHS**

Howard Manufacturing & Consulting, Inc.
3456 Altonah Road
Bethlehem, PA 18017
(215) 694-0939

Metrosonics, Inc.
P.O. Box 23075
Rochester, NY 14692-3075
(716) 334-7300 **PTM, WBGT**

Omega Engineering, Inc.
One Omega Drive
P.O. Box 4047
Stamford, CT 06907
(800) 826-6342 **RHS**

Quest Electronics
510 South Worthington
Oconomowoc, WI 53066
(414) 567-9157 **PTM**

Reuter-Stokes
Vallen Safety Supply
390 Turner Industrial Way
Aston, PA 19014
(215) 485-4715 **RHS, WBGT**

R.M. Young Company
2801 Aero-Park Drive
Traverse City, MI 49684
(616) 946-3980

Teletemp Corporation
P.O. Box 5160
Fullerton, CA 92635-0160
(800) 321-5160 **RHIC**

Vista Scientific Corporation
85 Industrial Drive
Ivyland, PA 18974
(215) 322-2255 **RHS, WBGT**

APPENDIX II

Sources for Obtaining Local Climate Profiles

NATIONAL WEATHER SERVICE AGRICULTURAL WEATHER SERVICE CENTERS

Midwest Agricultural Weather Service Center
Poultry Science Building
Room 220
Purdue University
Lafayette, IN 47907-5607
(317) 494-4317

Southwest Agricultural Weather Service Center
Texas A&M University
Soil & Crop Science Building, Room 341
College Station, TX 77843
(409) 846-3216

Southeast Agricultural Weather Service Center
P.O. Box 2246
Auburn, AL 36831-2246
(205) 844-4514

Mid-South Agricultural Weather Service Center
P.O. Box 306
Stoneville, MS 38776
(601) 686-9311 Ext. 275

REGIONAL CLIMATE CENTERS

Western Regional Climate Center
5625 Fox Avenue
Reno, NV 89506-0220
(702) 677-3100

High Plains Climate Center
237 L. W. Chase Hall
University of Nebraska-Lincoln
Lincoln, NB 68583-0728
(402) 472-6706

Midwestern Climate Center
Illinois State Water Survey
2204 Griffith Drive
Champaign, IL 61820
(217) 333-6780

Southeastern Regional Climate Center
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Capitol Center Suite 1100
Columbia, SC 29201
(803) 737-0800 or 0811

Northeast Regional Climate Center
1113 Bradfield Hall
Cornell University
Ithaca, NY 14853
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Fax (307) 766-3718

APPENDIX III
Methods for Deriving Tables 6 and 7

Method for Table 6
APPROACH FOR SETTING WORK/REST PERIODS FOR WORKERS WEARING NORMAL WORK CLOTHING

Abbreviations:

- Ta = air temperature
- Twb = wet bulb temperature
- Tg = globe temperature
- WBGT = wet bulb globe temperature
- Tnwb = natural wet bulb temperature

1. From psychrometric chart at right, read Twb for Ta between 90° and 112°F at relative humidities of 10%, 20%, 30%, 40%, 50%, and 60%.

2. WBGT ≅ .7 Twb + .3 Ta when there is natural ventilation with perceptible air flow and Tg = 0. Calculate ≅ WBGT with no radiant heat for the temperatures and relative humidities in #1.

3. (See Table A.)

   A. Calculate (Ta - WBGT) for air temperatures (90°F to 112°F) at relative humidities between 10% and 60%. (Second column, Table A)

   B. Calculate mean (Ta - WBGT) under each relative humidity. (Third column, Table A)

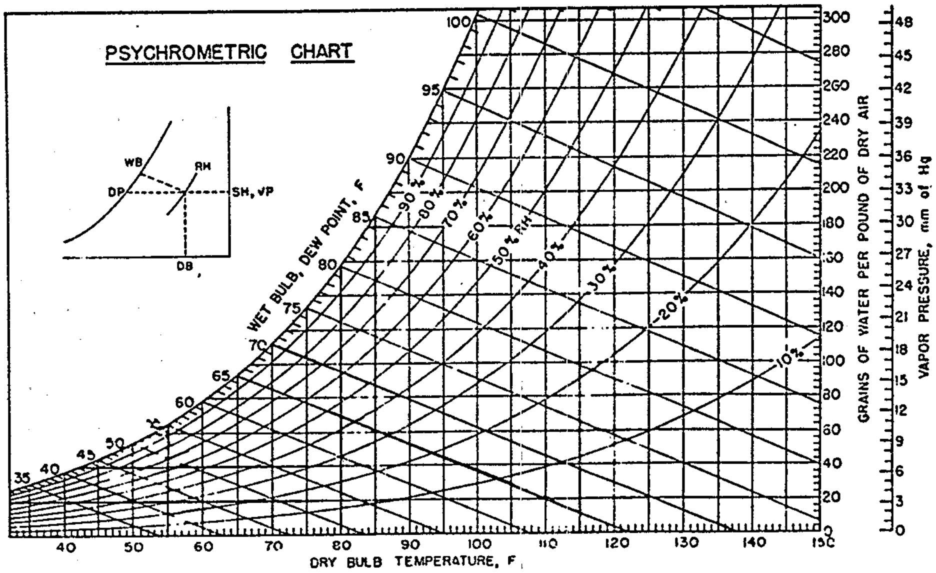
   C. Designate a median reference relative humidity. (30% was chosen, although any relative humidity in this range will serve this purpose.) Calculate differences between means for relative humidities of 10%, 20%, 40%, 50%, and 60% and the mean for 30% relative humidity. (Fourth column, Table A)

   D. Round off values in 3.C. to assign adjustment factors for each relative humidity.

   E. Assign air temperature adjustment factors for radiated heat of the sun as follows:

   - No sun — no adjustment.
   - Partly cloudy — add 7°F.
   - Full sun — add 13°F.*

PSYCHROMETRIC CHART AND VAPOR PRESSURE NOMOGRAPH



Source: The Industrial Environment — Its Evaluation and Control, 3rd Edition. NIOSH Publication No. 74-117.

Table A

AIR TEMPERATURE ADJUSTMENT FACTORS FOR RELATIVE HUMIDITIES AT AIR TEMPERATURES BETWEEN 90° AND 112°F

Relative Humidity	Range Ta - WBGT	Mean	Difference from 30%	Adjustment Factor
10%	22.26 to 29.47	25.87	8.37	–8°
20%	18.9 to 24.5	21.7	4.2	–4°
30%	16.1 to 20.3	17.5	---	---
40%	13.09 to 15.19	14.14	3.36	+3°
50%	10.5 to 12.88	11.5	6	+6°
60%	8.05 to 9.87	8.96	8.54	+9°

*Adjustment factors for relative humidity derived from a concept in Jerry D. Ramsey, "Practical Evaluation of Hot Working Areas," *Professional Safety*, February 1987. References 17 and 43 were also consulted. Adjustment factors for radiated heat of the sun derived from a concept in NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, Table 8-10, 1985. Ramsey's approach for estimating WBGT indoors is:

If, Air temperature warm—hot (Ta ≅ 75-95°F)
Natural ventilation with perceptible air flow (Twb ≅ Tnwb)
Minimal or no radiation (Tg ≅ Ta)
Then, At a given relative humidity, Tnwb ≅ Ta - (Ta - Twb)
And, . . . WBGT ≅ Ta - 0.7 (Ta - Twb)

4. Use ACGIH Threshold Limit Values and NIOSH Recommended Exposure Limits for heat stress exposure for heat-acclimatized workers.‡ (Table B)

5. Rearrange Recommended Exposure Limits, showing adjusted air temperature equivalent at 30% relative humidity and add intermediate values. (Table C) Include qualifying assumptions in a footnote to Table 6 in main text.

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‡ACGIH (American Conference of Governmental Industrial Hygienists), *1990-1991 Threshold Limit Values*, and NIOSH (National Institute for Occupational Safety and Health), *Occupational Exposure to Hot Environments: Revised Criteria 1986.*

Table B

ACGIH AND NOISH RECOMMENDED LIMITS FOR HEAT STRESS EXPOSURE FOR ACCLIMATIZED WORKERS

Light Work	Minutes of Work/Hour
87°F WBGT	45
89°F WBGT	30
90°F WBGT	15
102°F WBGT	Ceiling Limit

Moderate Work	Minutes of Work/Hour
82°F WBGT	45
85°F WBGT	30
88°F WBGT	15
98°F WBGT	Ceiling Limit

Heavy Work	Minutes of Work/Hour
78°F WBGT	45
82°F WBGT	30
86°F WBGT	15
95°F WBGT	Ceiling Limit

Table C

APPROACH FOR SETTING WORK/REST PERIODS FOR WORKERS WEARING NORMAL WORK CLOTHING

Ta*	WBGT	Light	Moderate	Heavy	Minimum Water to Drink
90	74	Normal	Normal	Normal	
91	75	Normal	Normal	Normal	
92	75.7	Normal	Normal	Normal	
93	76.6	Normal	Normal	Normal	
94	77	Normal	Normal	Normal	
95	78	Normal	Normal	45/15	
96	79	Normal	Normal		
97	80	Normal	Normal	[40/20]	
98	80.5	Normal	Normal		
	81	Normal	Normal	[35/25]	
99	81.5	Normal	Normal		
100	82	Normal	45/15	30/30	½ pint
101	83	Normal	[40/20]		every
102	84	Normal	[35/25]	[25/35]	30 minutes
103	84.6	Normal			
	85	Normal	30/30	[20/40]	½ pint
104	85.5	Normal			every
105	86	Normal	[25/35]	15/45	15 minutes
106	87	45/15	[20/40]	Caution	
107	88	[40/20]	15/45	Caution	
[108]		[35/25]	Caution	Caution	½ pint
[109]	89	30/30	Caution	Caution	every
110	90	15/45	Caution	Caution	10 minutes
111	91	Caution	Caution	Caution	
112	92	Caution	Caution	Caution	
	93	Caution	Caution	Caution	
	94	Caution	Caution	Caution	
	95	Caution	Caution	Stop work	
	96	Caution	Caution		
	97	Caution	Caution		
	98	Caution	Stop Work		
	99	Caution			
	100	Caution			
	101	Caution			
	102	Stop Work			

**30% relative humidity*

Method for Table 7
APPROACH FOR SETTING WORK/REST PERIODS FOR WORKERS WEARING CHEMICAL—RESISTANT SUITS

1. Work/rest periods are based on Goldman's table for Level C protection* — Tyvek coveralls with gloves, boots, and respirator — and adjusted + 5°F for heat-acclimatization. (Table D)
2. (See Table E.)

   A. Add 5°F to account for radiated heat of the sun under partly cloudy skies.

   B. Add 13°F for full sun and assign intermediate values for work/rest periods.

Table D

LEVEL C PROTECTION,* NO SUN, ADJUSTED +5°F FOR HEAT ACCLIMATIZATION

Air Temperature	Light Work	Moderate Work	Heavy Work
75°F	No restriction	No restriction	No restriction
80°F	No restriction	No restriction	No restriction
85°F	No restriction	No restriction	40/20
90°F	40/20	25/35	15/45
95°F	15/45	0	0
100°F	0	0	0

*Ralph F. Goldman, *Internal Report: Heat Stress Management Protocol,* Office of Research and Development, U.S. EPA, November 1989.

Table E

APPROACH FOR SETTING WORK/REST PERIODS FOR WORKERS WEARING CHEMICAL-RESISTANT SUITS

Air Temperature	Work/Rest Periods									Minimum Water to Drink
	—Light Work—			—Moderate Work—			—Heavy Work—			
	Full Sun	Partly Cloudy	No Sun	Full Sun	Partly Cloudy	No Sun	Full Sun	Partly Cloudy	No Sun	
75°F	Normal schedule	Normal schedule	Normal schedule	Normal schedule	Normal schedule	Normal schedule	35/25 [88°]	Normal schedule	Normal schedule	One half pint every 30 minutes
80°F	30/30 [93°]	Normal schedule	Normal schedule	20/40 [93°]	Normal schedule	Normal schedule	10/50 [93°]	40/20 [85°]	Normal schedule	One to 1½ pints every 30 minutes
85°F	15/45 [98°]	40/20 [90°]	Normal schedule	10/50 [98°]	25/35 [90°]	Normal schedule	Caution	15/45 [90°]	40/20	One pint or more every 15 minutes
90°F	Caution	15/45 [95°]	40/20	Caution	Caution	25/35	Stop work	Caution	15/45	Same as above
95°F	Stop work	Stop work	15/45	Stop work	Stop work	Stop work	Stop work	Stop work	Stop work	Same as above

Adjusted air temperature values that account for radiated heat of the sun are given in brackets.

APPENDIX IV

Background on the Fighter Index of Thermal Stress*

The Fighter Index of Thermal Stress (FITS) is designed for easy use by operational units to predict when cockpit environmental conditions during low-level missions may jeopardize aircrew performance.

FITS must be recognized as a specialized tool. Simplifying assumptions limit its use to most low-level flight (< 3000 feet) in fighter and trainer aircraft, both single and dual seat, with high-visibility bubble canopies and aircrews wearing lightweight flight suits. Data collected in flight indicate that there is a relationship between ground weather and cockpit conditions at altitudes less than 3000 feet above ground level.

The three zones indicated on the FITS tables are interpretation guides. They are not exact demarcation lines, but represent the FITS values at which most personnel will begin to experience the heat-stress problems as outlined. Before encountering problems, an individual aircrew member may withstand more or less heat stress than is indicated. This is because the terms "ground standby" and "low-level flight" encompass a range of activities, clothing requirements, and physiological conditions that cannot be incorporated into a simple index. As with any index, FITS is like a map rather than an aerial photograph, and its precision suits the general environment in which it is to be used.

Designation of Caution and Danger Zones on the FITS table seemed the most practical way to alert users to the significance of high readings. Since thermal physiology involves relatively slow processes, flight must be treated as but one item in a sequence of events involving different environments and metabolic rates. The specific limits were set after thorough review of the literature on the physiological and performance effects of heat stress, relating these to typical conditions encountered by aircrews.

Although FITS estimates cockpit conditions during low-level flight, the numbers also indicate levels of heat stress during the ground and low-altitude portions of all flights. This is the basis for recommending cancellation of all nonessential flights whenever the index exceeds 114.8°F WBGT. (WBGT is a specialized index of heat stress which accounts for the effect of humidity and air movement, air temperature, and radiation. WBGT is not normally reported by weather stations.) At this level, even minimum preflight and climbout times constitute a significant drain on physiological reserves which can compromise performance in later phases of the flight.

For light to moderate work, multiple studies show that a deep-body (rectal) temperature of 100.4°F is the upper limit desirable. Above this temperature, mental performance can be impaired, acceleration (G) tolerance diminishes, and human thermoregulation becomes inefficient. In fact, as deep-body temperature exceeds 100.4°F, an increasing number of persons approach collapse; and at 102.2°F, about 50% of subjects are incapacitated.

USAF fighter crews are apt to be more physically fit and better heat acclimatized than most other subjects used in reported studies, and thus can be expected to perform their work in hotter environments without increased risk of physiological compromise despite their heavier clothing.

Potential users should clearly recognize the limitations of FITS. The nature of the data used and simplifying assumptions restrict its application to fighter/trainer aircraft on missions involving significant periods at or below 300 feet above ground level. Exposure limits provide only general guidance, outlining conditions where a significant proportion of persons are expected to encounter problems.

*Derived from Stribley, R. F., and S. A. Nunneley, 1978. Fighter Index of Thermal Stress: Development of Interim Guidance for Hot-Weather USAF Operations. USAF School of Aerospace Medicine, SAM-TR-78-6; and Nunneley, S. A., and R. F. Stribley, 1979. Fighter Index of Thermal Stress (FITS): Guidance for Hot-Weather Aircraft Operations. *Aviation, Space, and Environmental Medicine*, 50(6):639-642.

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Washington, DC 20460